Distributed Multimedia Technologies and Value Chain Structuring

An Economic Theory of Communications

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Distributed Multimedia Technologies and Value Chain Structuring –

An Economic Theory of Communications

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This Doctoral thesis investigates the interaction between technological changes and societal transformations, more specifically the changes in information and communication technologies (ICTs) e.g. the development of the Internet, and how they interact with the economic transformations within a particular industry. In doing this emphasis is put on the enhanced abilities to create and transmit information emerging with developing ICTs. Applied ICTs hold economic potential to upgrade integration of production processes with consumer preference, for provision of new services and for a restructure of production organisations and value chains. Evidences of imperfect markets and a strict conviction on the insufficiency of conventional economic theory have fuelled the research-processes. Indeed economic theory suggests perfect information and balanced markets, but frequent market-imbalances suggest that the assumed conditions about information-access should be challenged. Innovations and applications of ICTs are analysed from the perspective that they will enable commercial information, reduce restrictions on information and lead to better market-operations.

Applications of these technologies have been investigated within the Danish textile and clothing industry, which provides a good example for multiple reasons: Firstly, it is a domestic industry that is highly dependent on global production-processes, which strain the suitability of personalised meetings. Secondly, a vast number of small and medium-seized enterprises dominate the industry, which both call for distributed value chains and intensive communications. And thirdly, continuous product-changes, sell-outs and business-terminations indicate evident market imbalances and potentials for applied ICTs.

In the following pages there will be an introduction to the developmental traits of ICTs and how they support information and communication processes. There will also be a more comprehensive preface to the selected case of the research, just as there will be an outline of the performed research-programme and the structure of this thesis. However, firstly there is a more general introduction to the impacts from technological innovations and societal changes.

Technological Changes and Societal Transitions

It has been argued that our modern society is in constant modes of transformation, which impact how we perceive ourselves, organise society and the production-processes[1][2]. In contrast to the flavours of consistency found in industrial and indeed pre-industrial societies, the modern or post-modern society is much more sporadic, dynamic and fragmented. Transformations of societies have increasingly led to

[1] Held, David et al. (eds.) (1990): "State and Societies", Basil Blackwell, Introduction, pp. 1-58.
[2] Lasch, Christopher (1979): "Narcissismens Kultur" (The Culture of Narcissism), Gyldendal, Copenhagen.

formation of sub-cultures and individualisation of expressions, politics and ethics, which challenges the established societal structures[3]. Essential to these processes is that information expands in volume and in reach: information is extractable at any location and transmittable to anybody. As information levels and transmission abilities grow we all get potential to be connected through one global information-highway[4]. Viability and power increasingly rest with access to information.

Concurrently with the globalisation, processes of individualisation have become evident: tastes, ethics and expressions get individualised. Technological changes not only transform the information-processes and societal relations, but also have a direct impact on productions and service provisions:

> "A technological revolution, centred around information technologies, is reshaping, at accelerated pace, the material basis of society... Capitalism itself has undergone a process of profound restructuring, characterised by greater flexibility in management; decentralisation and networking of firms both internally and in their relationships to other firms; considerable empowering of capital vis-à-vis labour, with the concomitant decline of influence of the labour movement... intervention of the state to deregulate markets selectively, and to undo the welfare state, with different intensity and orientation..." (Castells, 1998[5]).

Through technological changes the economic structures change: new information technologies induce a new economy, centred on speed, flexibility, decentralisation, differentiation, and targeting[6]. Indicators of the New Economy are related to occupational changes from manufacturing to service provision, globalisation of markets and provisions, more dynamic competitions and an IT-revolution with improving computing abilities, transmissions capacities and deregulation of tele-sectors[7]. Indeed these societal transformations have been connected to developments of a service economy, where information and services increasingly get integrated in productions and hence the traditional distinctions between service and production becomes unrealisable[8].

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[3] Galbriath, John Kenneth (1971): "The New Industrial State", Penguin Books, London.
[4] Negroponte, Nicholas (1995): "Being Digital", Hodder & Stoughton, London.
[5] Castells, Manuel (1996): "The Rise of the Network Society", Vol. 1, Blackwell Publishers, Oxford, pp. 1-2.
[6] Amin, Ash (ed.) (1999): "Post-Fordism, A Reader", Blackwell, Oxford.
[7] Atkinson, Robert & Randolph Court (1998): "The New Economy Index", available at www.ppionline.org, November 1998, pp. 1-50.
[8] Bressand, Albert et al. (1989): "Networks at the heart of the service economy", in Albert Bressand et al (eds.): "Strategic Trends in Services", Harper Row, New York, pp. 17-32.

Table 1.1: Old and New Economics

Issues	Old Economy	New Economy
Economy-wide characteristics		
Markets	Stable	Dynamic
Competition	National	Global
Organisational form	Hierarchical	Networked
Industry		
Organisation	Mass Production	Flexible Production
Key drivers	Capital/Labour	Innovation/Knowledge
Key technologies	Mechanisation	Digitisation
Competitive advantages	Economics of scale, costs	Innovation, quality, time
Business relations	Individualised	Alliances & collaboration

Belabouring of Atkinson & Court, 1998[9].

Enhanced service- and information-levels in production and consumption draw attentions towards integration in production and relationships management in provision of mass-customised items. Consumers increasingly dictate personalised preferences before manufacturing processes starts: value structures shifts from mass-produced supply-pushed provisions to production-on-demand, and consumption gets interwoven with production: "prosuming" emerge[10].

Developments in ICTs have not only implied a new and better infrastructure for information and communications but have due to its profound reach implied substantially altered conditions. Computing and information processing serve not only a single industry but reach into all economic spheres. First and foremost, the changed conditions of ICT-provisions have altered the industrial landscape through growth of the information and telecom sectors: it is the information carriers, and not the content providers that gain the most[11]. The tele-sector has increasingly become liberalised, exposed to competitions from other carriers and development of competing access technologies, which have shifted the levels of services and modes of pricing[12]. And industrial changes have been profound

[9] Op cit: Atkinson & Court (1998), p. 7.
[10] Toffler, Alvin (1990): "Magtskifte", (Powershift), Holkenfeldt, Copenhagen.
[11] Adlyzko, Andrew (2000): "Communications: grit and glamour, or why content is not King", in Andrew Adlyzko: "The history of communications and its implications for the Internet", available at www.research.att.com/~amo/doc/networks.html December 2000, pp. 12-31.
[12] Melody, William (1997): "Telecom Reform", Technical University of Denmark, introduction, pp. 1-10.

within the semiconductor and computer industries that have become truly global[13], and grown in size and value[14].

Alterations at the technological frontiers impact different industrial sectors differently. Impacts from applied ICTs have been substantial on industrial sectors that provide information services e.g. finances[15] and insurance[16], or provide other services like transport and logistics[17]. Whereas the information-providing and -processing industries have experienced substantial gains the conventional manufacturing industries have been impacted less directly[18]. In contrast to the telecom industry, the manufacturing industries gain from the information content rather than the transmission-processes. And in contrast to the service-providing enterprises, their core value-adding activities and products cannot be transmitted electronically. Economic gains from applied ICTs in the manufacturing industries consequently relate to abilities to extract and transmit information in production and in service provision[19].

Through information sharing the businesses are granted direct information about demand and supply, market developments and competition. Direct and accurate information provides opportunities to improve demand forecasting, supplier-evaluation, trend-analyses etc. Information hence impacts the general understanding of the competitive environment and enables an improved responsiveness to changes. However, even for a manufacturing industry the ICTs also impact the production-processes through digitisation of some operations. One evident field of impact is the administrative tasks and back-office operations that are supported through production and financial data exchanges. Digitisation improves both routine administrative operations and reduces the costs of transacting with other businesses. Another field of digitisation is found in some value-adding processes like product-designs and computerised assembly. The design-processes have the potential to become totally digitised and hence will these services be subject to electronic transmissions and possibly outsourcing.

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[13] Henderson, Jeffrey (1991): "The Globalisation of High Technology Production", Routledge, London.
[14] Cohen, Stephen S, et al. (2000): "Tools for Though: What Is New and Important About the "E-conomy"?", BRIE Working Paper #138, available at http://brie.berkeley.edu/~briewww/pubs/wp/wp138.html January 2001.
[15] "The Tradability of Banking Services: Impact and Implications" (1994), Current Studies Series, No. 27, United Nations, Geneva, "Information Technology, Services and Tradability", pp. 1-12.
[16] Falch, Morten (1998): "Electronic Distribution and cross-border trade in Insurance Services", in Electronic Markets, Vol. 8, pp. 10-13.
[17] Falch, Morten et al (1994): "EDI i transportsektoren", (EDI in the transport sector), in Morten Falch et al (eds.): "EDI – en elektronisk infrastruktur" (EDI – an electronic infrastructure), DATE report no. 6, Center for Tele-Information, pp. 69-87.
[18] European Information Technology Observatory, 2000.
[19] Shapiro, Carl & Hal Varian (1999): "The Information Economy", in Carl Shapiro & Hal Varian: "Information Rules", Harvard University Press, Introduction, pp. 1-18.

A third important field of digitisation is in management where ICTs increasingly support production-control, logistics, negotiations, market surveys etc.

Ability to transmit production data, valuable information and services founds the commercial potentials from applied ICTs in the manufacturing industries. These potentials rest with the content of transmitted data, its support for value chain operations, and with transmissions of information services and products through the electronic networks. Or phrased differently in defining electronic commerce as;

> "A modern business methodology that addresses the needs of organisations, merchants, and consumers to cut costs while improving the quality of goods and services, and increasing the speed of service delivery. The term also applies to the use of computer networks to search and retrieve information in support of human and corporate decision-making. More commonly, e-commerce is associated with the buying and selling of information, products, and services via computer networks today and in the future via any one of the myriad of networks that make up the information Superhighway" (Strader & Shaw, 1997[20] - with a reference to Kalakota & Whinston, 1996[21]).

Looking at the impact on various industries from applied ICTs it must be questioned to what extent that new information technologies also call for new economic rules. Some arguments emphasise the transmittability of information, services and products have also stressed the need for new rules: the new information-sharing possibilities lead to new behaviours inexplicable by established theories; a new theoretical paradigm becomes needed[22&23]. An important element of the New Economy relates to the nature of the information infrastructure. Network externalities exist which leads to positive feedback; more users of a given structure will enhance the values to all users[24&25]. Through gradual path-dependent developmental trait first-mover advantages become evident and the winning standard will subsequently out-perform competitors, not from better endowments but from sheer numbers[26]. However, it seems less clear that the information-technological paradigm should prevail in the manufacturing industries too. At least it should be contested that all industrial sectors get impacted

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[20] Strader, Troy & Michael Shaw (1997): "Characteristics of Electronic Markets", in Decision Support Systems, Vol. 21, pp. 185-198.
[21] Kalakota, Ravi & Andrew Whinston (1996): "Frontiers of Electronic Commerce", Addison-Wesley, Wokingham, England.
[22] Freeman, Christopher (1988): "Economic issues", in IEE Colloquium on 'Information Technology – Engineering the Future'", Digest No. 23, pp. 1-3.
[23] Freeman, Christopher (1988), introduction to Giovanni Dosi et al (ed.): "Technical Change and Economic Theory", Pinter Publishers, London.
[24] Arthur, Brian (1990): "Positive feed-backs in the economy", in Scientific America, pp. 80-85.
[25] David, Paul (1992): "Information Networks Economics – Externalities, Innovations and Evolution", in Cristiano Antonelli (ed.): "The Economics of Information Networks", Elsevier Scientific Publishers, The Netherlands, pp. 103-106.
[26] Kelly, Kevin (1999): "New Rules for the New Economy", Penguin Books, New York.

equally, and that new rules are needed: different combinations of known theoretical approaches are capable of describing the economic actions in various industries[27].

Questions have arisen on the need, relevance and weight of different economic theories. Especially, questions should be posed on how conventional manufacturing industries get impacted by applied ICTs and how these impacts can be understood from known economic theories. In order to deal with this kind of questions, the research-process undertaken in this thesis has been to investigate the general developmental traits of ICTs and the industrial applications. Through analysis of the interactivity between technology and industry some general observations have been identified and compared to the explanations offered by established economic theories.

Research Programme

Considering the wide field of applications and the rapid technological changes there can be no doubt that applied ICTs have potential to inflict major societal transformations. However, it seems less clear how individual firms and different industrial segments get impacted, and to which extent we need a new methodological approach. To assess the impacts from developing ICTs we need a thorough understanding of the industrial operations and for analyses of the interaction between technological changes and industrial organisations. One such contribution is offered in this doctoral thesis. The position taken here is that applied ICTs enable new forms of information sharing and for businesses to interact electronically. Altered information-processes change the commercial abilities, enhance market responsiveness, and facilitate improved correspondence between market demand and supply.

The research-steps undertaken in this programme have continuously shifted between theoretical analyses of economic activities, case study of the industrial structures, and investigations of the emerging ICTs. Through continuous analyses in all three fields it has been possible to make continuous investigations, hypothesis posing and testing. Construction of research hypotheses have led to data analyses and verification attempts, which in turn have inspired construction of new and better hypotheses. This iterative process has been fruitful in analysis of the explanatory powers of established economic theories. Consequently the iterative processes have enabled construction of an alternative analytical model that captures the core elements of the industrial structures and some of the potential impacts from applied ICTs. The thesis does not describe the historic developments of the analytical

[27] Shapiro, Carl & Hal Varian (1999): "Networks and positive Feedback", in Carl Shapiro & Hal Varian: "Information Rules", Harvard University Press, Introduction, pp. 173-225.

processes that have led to the construction of the analytical model, but instead it offers a introduction to the thoughts behind the research-process and its results.

Technological Developments

ICTs have developed rapidly within past decades. Information technologies improve as computers' processing-abilities increase, storage-capacities multiply, and hard- and software programmes increasingly support interactivity and sharing of files. Concurrently, abilities of computers to interact in distributed networks have enhanced due to improvements in access technologies e.g. modems and enlarged bandwidth in data transmissions. Technological improvements have enabled distributed interactivities with transmissions of multimedia files i.e. distributed multimedia (DMM). DMM-technologies support the simultaneous application of several media e.g. text, graphics and video, and a distributed interactivity. Combined these features are instrumental in forming shared workspaces for product developments, videoconferencing for personal meetings and communication etc. ICTs have great potential in support for information sharing e.g. e-mails, electronic funds transfers, electronic data interchange (EDI), shared databases and the like. These structures also encompass some dialoguing and interactive facilities like answered e-mails, the shared databases, chat-groups etc. An additional, important feature of some DMM-technologies is the simultaneous application of multiple media, which enable virtual meetings and shared workspaces. Most web-pages are based on DMM-technologies but only offers low degrees of interactivity e.g. browsing through pages and links to e-mail. Recent technological developments have shifted the boundaries of the interactive attributes of DMM-technologies, and consequently they look promising in providing truly distributed interactivity.

Distributed interactivity hinge on abilities of computers to get connected in electronic networks, at sufficient bandwidth and smooth programme-interfaces. Through establishments of universal transmission protocols, new network switching functionalities and increased bandwidth, the established telephony networks and other communication lines become suited for transmitting large data volumes. Interconnectedness of computers has historically been restricted by proprietary communication-standards but has lately become boosted by diffusion of more standardised and easy-to-use communication-protocols on the Internet e.g. the http (Hyper-Text Transmission Protocol applicable for the Internet). Standardisation of communication tools enable wider accessibility of data on the Internet, just as universal compression standards like MPEG (Moving Picture Experts Group, coding for audio-visual information) and image-processing tools (like Java) support transmissions and viewing of images and videos essential to the distributed interactivity. The rapidly increasing transmission-abilities and services have developed without substantial increases in the

communication-costs, indeed telecommunication have dropped in many countries as more users have shared the fixed costs of networks, liberalisation of the telecommunication sector has increased competitions, and as competing access technologies have emerged[28].

Concurrently with the increasing computing and transmitting abilities of ICTs and DMM-technologies, they increasingly get diffused: to more individuals, businesses, industries and economic regions[29]. Digitised information-services for commercial purposes e.g. electronic sales through web-pages, e-mail, EDI-messaging and electronic funds transfers are rapidly diffusing. Internet penetration and electronic commerce potentials are high notably in North America and the Nordic countries, but also in other parts of Western Europe. Application levels are growing fast in other parts of the world too: notably in the Asian tiger-countries but also in the rest of Asia and Eastern Europe. As ICTs get diffused to more countries and regions the abilities to share information and to communicate, the commercial prospects increase, more services get introduced and information processes may eventually become truly global.

Though the global Internet-access is still quite low and there are only modest applications of DMM-technologies, the world becomes increasingly interconnected in an electronic network. Most ICTs are supportive for the commercial activities like transacting and transmissions of commercial data. Some of the most promising developments of the DMM-technologies are abilities to share multimedia files and for real-time media-rich communications[30]. Sharing of multimedia files is especially relevant for displaying developed products and potentials. Likewise the interactive functionality of sharing multimedia-files in shared workspaces enhances abilities of speedy, distributed product developments, and learning processes. Web-cameras and virtual meetings, which enable distributed human interactions, also assist knowledge formation and learning, but is also important for distributed monitoring and control mechanisms. These functionalities have promising potential for a manufacturing industry like the Danish textile and clothing industry, which is relying much on personal meetings and interactions. Though the potentials might be impressive, the diffusions of most DMM-technologies are still quite modest.

[28] Melody, William (2001): "Trends in European Telecommunication", for Telestyrelsen, National Telecom Agency, forthcoming, 48 p.
[29] European Information Technology Observatory, 1999.
[30] Daft, Richard & Robert Lengel (1986): "Organisational Information Requirements, Media Richness and Structural Design", in Management Science, Vol. 32, pp. 554-571.

Case profile

Analyses of applied ICTs and DMM-technologies in a manufacturing industry have been performed through investigation of the Danish textile and clothing industry. This industry is composed of numerous small and medium-sized enterprises (SMEs) where the manufacturing processes tend to be distributed amongst a range of specialised units. These separations and distributions of tasks to other firms imply some unique organisational challenges. Production organisers have to identify cooperating companies, sub-contractors, manage logistics, distributions, ensure quality etc. Through the past decades the industrial businesses have become increasingly interwoven both within industrial districts and also in operations: The textile industry, which include the first steps of the value-adding processes from spinning, weaving and knitting to colouring, have become integrated with the manufacturing industry, which includes the processing of the textiles into final garments e.g. designing, cutting and sewing[31]. Integration of these industries have partly been facilitated through technology- and process-innovations where the physical production steps get interwoven, and partly through information sharing and process integration where the industries increasingly rely on the other for inputs or orders[32]. As the industrial operations have become more interwoven and the industrial segments depend increasingly on each other, this doctoral thesis treats the textile and clothing industry as a single industry unless stated otherwise.

Danish textile and clothing industry has become exposed to increasingly competitive environments: production-technologies are relatively cheap allowing for manufacturing around the world, improved infrastructures leading to lower costs of transportation, high domestic labour-costs, and individualisation of tastes and preferences. These alterations have accelerated through the last decades epitomised by increased market-segmentations, smaller production-batches and rising levels of imports. Increasing import levels and even faster growing rates of exports have shifted the composition and internationalisation for this industry[33]. Domestic productions were able to satisfy domestic demands, but altered consumer preferences and increasing domestic production-costs have changed circumstances. Some labour-intensive tasks have become outsourced to low-cost countries, which are reflected in increasing exports of Danish textiles to these countries and increasing imports of clothing[34]. Changes in consumer preferences are also reflected in increasing levels of international

[31] Audet, Denis (1996): "Globalisation in the Clothing Industry", in "Globalisation of Industry – Overwiev and Sector Reports", OECD, pp. 323-355.
[32] Byrne, Chris (2000): "The Industrial and Social Impact of New Technology in the Clothing Industry into the 2000s", available at www.davidrigbyassociates.com/articles, February 2000, pp. 1-21.
[33] Maskell, Peter (1984): "Ensidige Industrikommuner" (Single-industry Municipalities), Copenhagen Business School.
[34] Illeris, Sven (1999): "Outsourcing of Textiles and Clothing Industry from Denmark to Baltic Transition Countries", available at www.geo.ut.ee/nbc/papers December 1999, pp. 1-5.

trade in finished garments amongst Western European countries associated with increasing levels of product differentiations[35].

Competitive strategies have been to introduce cost savings in the labour-intensive assembly-processes e.g. scientific management and international outsourcing, or to introduce lean production-processes i.e. small flexible productions on demand[36]. Abilities to construct lean structures and just-in-time provisions require intensive information-sharing structures, which are obtainable through application of ICTs. Information sharing between retailer and clothing manufacturers is crucial in order to gain knowledge about the market developments and for demand forecasting, which is greatly assisted by ICTs. Information sharing is essential both up and down-stream in value chains e.g. sales data from retail up-stream, and designs down-stream. Increasing Internet-connectivity and applied ICTs in administration and production impact the economic organisation through better market reaches, improved interactions with consumers, disintermediation, new and better service-provisions and upgraded value chain operations, expressed by improved market responsiveness and improved product qualities.

The analysed industry is a relevant case for analysing ICTs and DMM-technologies and information-processes in manufacturing industry due to a wide number of characteristics. Distributed production-processes call for intensive information sharing and exchanges of strategic information. Personal communications are essential to the present operations of the industry, but continuous globalisation will strain these arrangements and gradually compel businesses to apply electronic supports to overcome the geographical distances. Some important aspects of the manufacturing processes have become digitised notably design and sale, which enable new modes of outsourcing and interactions between consumers, retail and the industry. Intense, global competition penalises the non-optimal businesses and value chains that must resort to sales and discounts, or alternatively end up with sell-outs and lost commercial opportunities. Markets for textile and especially clothing have become exceptionally volatile and segregated, which have resulted in more difficult and less accurate demand forecasts. Due to the long production cycles and short-lived sales-period the industry is evidently venerable to mismatches between supply and demand. ICTs may be very fruitful tools in increasing market-knowledge and improve responsiveness.

[35] Nielsen, Kent (1993): "Industrielle netværk" (Industrial Networks), Systime/GAD, Denmark.
[36] Abernathy, Frederick et. al (1999): "A Stitch in Time", Oxford University Press.

Substantial parts of the business-operations are managed through personal meetings with the assistance of simple ICTs like the fax. But increasing competitive pressures and technological innovations make it more and more relevant for businesses to apply ICTs and DMM-technologies for commercial operations and in more geographical regions. ICTs are supportive for the management of value chains, and DMM-technologies are especially applicable in sharing information and for distributed communications. Web-based monitoring, shared workspaces and videoconferencing are some emerging DMM-technologies, which slowly get more diffused and applied for commercial processes. These technologies hold vast economic potential related to product-developments, improved monitoring and personalised communications with business-partners e.g. in formations of trust, shared knowledge and learning. The case study reveals to what extent the communicative technologies get applied and for which purposes.

Research Contributions

Continuous discrepancies between supply and demand expressed in frequent sell-outs and heavy discounts indicate that conventional economic theoretical contributions are ill-suited to explain the industrial operations within textile and clothing. Apparently there seem to be mismatches between the producers' expectations and the final consume. Given the wide range of products, qualities and prices of the items in the industry, the mismatches seem to be related to misunderstood or lacking information when the producers estimate final demand.

At the same time a string of new information technologies has developed, which enable information sharing and communications at an entirely new level. ICTs and notably DMM-technologies are potential channels for sharing information and data about markets, products, prices etc., which can assist producers and production owners in their decision-taking. Some of the noteworthy entities of the ICT-developments are trends towards lower telecommunication-prices, high bandwidth and data transmission-capacities, lower computing costs, and a wider reach of the Internet both in geographical areas and with more nodes. These trends points to the eased communication-processes both between consumers and producers, and between contractor and sub-contractor, which may alter the production-processes, market understandings and demand-forecasts. Applied ICTs hold the potential to improve information access and commercial operations, which will improve the competitiveness of businesses and industries.

Puzzlements over the apparent discrepancies between the poor industrial operations and emerging cheap ICTs and DMM-technologies have lead to formulation of a range of questions: Which intrinsic

values do DMM-technologies encompass and which commercial operations do they support? To which degrees have ICTs and DMM-technologies been applied by industry, and how does the application of such technologies impact the commercial operations? And which implications do the enhanced communication technologies have on the economic activities and how are they comprehended in economic theory?

These questions and others have been analysed within the realm of this thesis. The analytical processes have been structured around iterative processes based on data-collections and theoretical analyses, which have led to construction of some predictions or expectations. These predictions have subsequently led to additional data-collection and theoretical analyses, which in turn have led to new predictions. The iterative processes have unfolded between the areas of economic theory, technological investigations and the industrial case study. Through initial theoretical analyses, technological investigations and the case study it has been possible to make predictions on the applications of ICTs and how they impact industry. Discrepancies between these results and the applied theory have led to further theoretical analyses and some suggested modifications, which in turn have been tested on additional case data. These processes have been followed until the final construction of a communication model for the industry.

The academic solidity of the research hence relate to construction of a communication model, which can explain the communication processes identified within the industry. However, a methodological constraint has emerged due to the relative limited application of some ICTs within the industry. Some technologies like e-mail, the Internet, EDI (Electronic Data-Interchange) and CAD/CAM-files (Computer-aided design and manufacturing) have become widely applied for commercial operations. These ICTs point to some of the interactive properties of DMM-technologies, where businesses may interact irrespectively of physical distances. Hence, the applied ICTs support some interactivity but neither real-time virtual meetings nor seamless cooperative virtual workspaces. DMM-technologies like videoconferencing and virtual workspaces are not applied at any substantial scale yet.

Through the iterative research-processes it have become possible to make a comprehensive research of the interactions between applied ICTs and DMM-technologies, the industrial case and economic theory. Through the case study it has been possible to investigate the use ICTs and how they impact economic actions within an industry. Technological innovations within ICTs and DMM-technologies have been analysed in order to grasp the pros and cons of available technologies, and to understand their applicability. And economic theory has been studied in order to identify the economics of

information sharing and communications. Combined the three areas have contributed to construction of a communication model that explains the present communication processes in the industry and points to the potentials from applied DMM-technologies. The proposed communication model has firstly been validated on the available data and later been compared to the theoretical values of established theories.

Some of the important analyses and conclusions are included in this thesis. It has not been the intention to outline the analytical processes that have led to the communication model, but instead to offer an insight to the premises, analytical values and conclusions of the research. This has been attempted in the following through an outline of the communication model and the methodological conditions in chapter two. In the third and forth chapters there are outlines of the technological developments and industrial characteristics, respectively. In the fifth chapter there is an outline of the industrial value chains in the light of the communication model, which is followed by a chapter on economic theories that compares the analytical value of the model vis-à-vis other economic theories. Finally, in chapter seven there is a brief summary and outline of the main findings.

Chapter 2: Methodological Approach

2.1. Research Field and Questions

Research Question 1

Research Question 2

Research Question 3

Summary

2.2. Information and Communications in Economics

Information and Communications

Acts of Communications

Communications in Economics

Knowledge in Economics

Summary

2.3. The Communication Model

Knowledge Formation

Transacting

Value Chain Structures

Summary

2.4. Methodological Considerations

Methodology Approaches in Economics

Predictability Nexus

Explanatory Nexus

Summary

2.5. Conclusions

This chapter offers an outline of the methodological considerations and actions taken in preparation of this doctoral thesis. The driving forces behind undertaking this research have been to a wish to comprehend the changes in economic organisation and market operations in the light of improved Internet-based technologies. Special interest has been devoted to the role of communication within economic theory. The academic processes have focused on societal relations i.e. the transformation of economic organisation given emerging DMM-technologies. The analytical framework includes a detailed investigation of applied ICTs within a single industry, which offers some insight to the impact from emerging technologies and communication-abilities. It has been recognised that the industrial developments are not entirely technology-driven but depend on feedback from society, but this kind of feedback mechanisms seem very weak in the chosen industry. Analyses of human behaviours, societal relations and technological developments raise some methodological questions and challenges regarding research-methodology and validation processes, which is discussed below.

In the following sections there are discussions of the pursued research-questions, an introduction to information and communications in economic theory, a proposed communication model for analysing communicative and interactive abilities provided by ICTs and DMM-technologies, and finally there are some methodological considerations on how to answer the posed research questions. However, this chapter starts by an introduction to the research-field, how the selected case interacts with economic theory, and its impact on the research-questions.

2.1. Research Field and Questions

A precise formulation of the research-questions is an important element of the academic research-process. Iterative research-processes within grounded theory prescribe high levels of interactivity between investigating case-data, analysing theory, and posing the research-questions[37&38]. Such iterative processes have been assisting formulation of the actual research-questions for this thesis: through continuous analyses on economic theory combined with data-analyses on the industry and on emerging ICTs[39]. Initial analysis of the theoretical framework has lead to a set of questions that have shaped conditions for subsequent data collection and verification processes. These processes have in turn led to formulation of new analytical questions, theoretical reassessments and subsequently collections of new datasets.

[37] Orton, James D. (1997): "From Inductive to Iterative Grounded Theory: Zipping the Gap between Process Theory and Process Data", in Scandinavian Journal of Management, Vol. 13, no. 4, pp. 419-438.
[38] Strauss, Anselm & Corbin, Juliet (1998): "Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory", SAGE Publications, London.
[39] A more detailed account of the research processes and applied sources is offered in appendix A.

Grounded theory is primarily based on qualitative data. Methodological lines that stress the qualitative approach also emphasise the application of valid methods that enable constructions of general statements based on single events identified through the qualitative approach. Fundamental to iterative grounded theory is that the researcher continuously goes back and forth between inductive posing of hypotheses and data collecting for deductive analyses. "The main argument… is the assertion that organisational process researchers are creating a viable methodological position - iterative grounded theory - between inductive research and deductive research." (Orton, 1997[40]). Theoretical considerations lead to hypotheses and research-questions, which get falsified or verified through data-analyses. These results in turn inspires to new hypotheses, data-analyses and so forth.

Analyses of different economic theories, emerging ICTs and industry-specific characteristics have all been essential in formulation of the research-questions in this thesis. Economic theory offers a wide display of competing contributions both on industrial organisation, and on the roles of information and communication. Neoclassical economic theory suggests that all economic agents are rational and enriched by perfect information, and that demand is matched seamlessly with supply at costless markets. Situational analysis can refine the assumptions about information-access, but agents in principle remain rational in their pursuit of profits and utility[41]. Institutional and evolutionary economics instead integrate limited information-access and propose that agents be bounded rational, and sub-optimal in their behaviour: they apply some form of routine-based institutions in their optimising behaviours[42]. The transaction cost analysis epitomises the cost of information, and industrial analysis highlights the role of business units and strategies in interacting. Contributions on the New Economy epitomise the abilities to generate and shared information costlessly within networks.

These economic analyses all offer valuable insights into the industrial organisation in the light of improved information-access and communication-abilities. However, most of the theoretical contributions suffer from the shortcoming that information is thought homogenous as a quantitative entity: accessible to a lesser or wider extent and imbedded in more or less costs. Hence, these contributions only offer limited insight to the actual composition of communications and the communicative role of ICTs and DMM-technologies.

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[40] Op cit. Orton (1997), p. 421.
[41] Mäki, Uskali et al. (eds.) (1993): "Rationality, Institutions and Economic Methodology", Routledge, London.
[42] Hodgson, Geoffrey (1998): "The Approach of Institutional Economics", in Journal of Economic Literature, Vol. 36, pp. 166-192.

It is assumed in this thesis that ICTs continuously develop and increasingly support the communicative interactivity of DMM-technologies, and hence will alter the commercial possibilities and compositions of industrial interactions. ICTs hold different characteristics that make them supportive to commerce and required in production, organisation and decision-making. The use of electronically based exchanges of data has been applied for decades firstly as EDI and later in the form of e-mails. The Internet has also become an important media for transmitting both texts and non-textual messages such as images and audio. Other aspects of ICT-developments are deregulation of the telecom sector and improved transmission technologies, increasing hard- and software compatibilities and generally lower information costs. DMM-technologies include techniques that simultaneous apply more than a single media i.e. combinations of text, graphic, image, video and audio. Other important features of DMM-technology are the distributed ability to interact in virtual spaces, which supports both human-to-human communications e.g. through videoconferencing, and computer interactions e.g. in virtual workspaces.

Economic potentials from applications of these technologies on the industrial organisation are vast. Some of the most evident features relate to enhanced information sharing supported by ICTs: improved market analyses and demands forecasting, but also to lean production through supply chain management and just-in-time production organisation. Enhanced communication-abilities provided by the DMM-technologies also support tighter interactions between producer, retailer and consumers in product developments. DMM-technologies enable new modes of matchmaking where businesses can improve the human and computerised interactions in support for better determination of trustworthiness, skill-levels, monitoring and knowledge sharing. These communication-abilities have economic potentials by impacting value chain structures, productions qualities and management of operations.

Danish textile and clothing is one such industry that contains large potential gains from application of these technologies. This industry has through the past decades been subject to mounting levels of international competition from high-quality European garment and from low-cost Asian and Eastern European producers. Businesses in Denmark and other Western European countries have in order to maintain international competitiveness had to adjust production processes apply ICTs and DMM-technologies, apply strategies of product-differentiation, and outsourcing of sewing to low-cost countries. Value chains get structured within regional districts for access to specialised skills and resources, and international outsourcing emerge to reap the impressive savings in labour-costs.

On the demand-side there have been evident shifts towards individualisation of tastes and increasing demands for quality for both time and money. Specialised retailers are competing with internationalisation of markets, Internet-based virtualised outlets, and with supermarkets that offer cheap convenient shopping. Retailers have to provide increasing ranges of designs to satisfy individualised tastes, and have to minimise stock-levels to cut costs and prices. Competitive pressures are not only mounting in the retail link but transcend the entire value chains. New relations are emerging between sales-outlets and producers in order to ensure the correct supply at the right time and costs. And producers depend increasingly on their sub-contractors and suppliers in order to meet the accelerating demands for timing, costs and quality.

Various ICTs have been applied in order to satisfy the needs for flexibility and cost-minimisation. Barcoding and EDI-messaging have been widely applied as information sharing between retailers and manufacturers of clothing, and similar structures are also emerging between manufacturers and sub-contractors. Whereas web-cameras and videoconferencing are only slowly getting applied by the industry for virtual meetings, shared files in computer-integrated manufacturing have been applied for decades. These partial applications of the available DMM-technologies and potential commercial benefits from applying other functionalities raise questions on how to deal with the attributes from DMM-technologies, and how applications will impact the industry.

Research Question 1:

What are the theoretical contributions on information and communication in economics, and what is the role of communication in the industrial processes?

The role of information has been given different weight and attention in economic theory through time. Important determinants seem to be the historical attention to information and the level of theoretical abstraction.

Neoclassical economic theory offers a very simplistic perception of information in market operations, as information is assumed to flow freely and is accessible to all at no costs. Later theoretical modifications based on less abstract analyses have suggested some limitations to information-access[43] and processing-abilities[44].

[43] Stigler, George (1961): "The Economics of Information", in Journal of Political Economy, Vol. 69, pp. 213-225.
[44] Simon, Herbert (1995): "Bounded Rationality and Organisational Learning", in Michael Cohen & Lee Sproull (eds.): "Organisational Learning", Sage Publications, London, pp. 175-187.

New institutional and evolutionary economics have offered another economic perspective on industrial organisation and the role of information. Institutions are in these theories not just habits but self-reinforcing elements that develop and interact with individual agents. Contributions include transaction cost analysis that argues for limited information-flows and costs of information processing[45]. Industrial economics e.g. in the form of industrial district analysis argues for localised information-processes, and evolutionary economics argue for limited processing-abilities and limited information-access impacting routine-based decision-making. Communication is viewed as basic processes for learning[46].

Latest contribution on the role of information in industrial organisation is found in New Economics that much like neoclassical theory suggests that information be free and easily accessible. Attention is devoted to new ICTs, their compatibility, common communication-standards, their potential to separate information from production processes, and the provision of information services. A focal element seems to be technological compatibility and communication-abilities of technological standards, based on path-dependent developments[47].

Questions mount on the theoretical contributions and their ability to handle qualitative aspects of information: what are the economic contributes from communications and how do they impact on the industrial processes? How is information perceived analytically and to what extent is optimal industrial organisation dependent on smooth information-access and communication-abilities? And what will the impacts from increased communication-abilities be on market-performances and structures?

Research Question 2:

What are the information- and communication-requirements for businesses in the textile and clothing industry, and how do applied ICTs and DMM-technologies satisfy these needs?

Firms are organisational entities that seek to satisfy business-strategies and reach economic goals paying due respect to available resources and involved risks. Information is required by businesses for analysing competitive environment, identifying opportunities and for formulating business-strategies.

[45] Williamson, Oliver (1975): "Markets and Hierarchies: Analysis and Antitrust Implications", Collier Macmillan Publishers, London.
[46] Lundvall, Bengt-Åke & Björn Johnson (1994): "The Learning Economy", in Journal of Industry Studies, Vol. 1, pp. 23-42.
[47] Shapiro, Carl & Hal Varian (1999): "Information Rules", Harvard University Press.

Information transcends all economic activities and information sharing is essential for businesses to operate and react to changed conditions. Information is not just a quantitative entity but founds the base for qualitative communication that enables individual and organisational learning and knowledge-formation. Knowledge is exchangeable through communications, formed as information is accessed, and comprehended by individuals and embedded in organisational structures. Knowledge on why, what and how to produce is as essential as knowing who to work with.

ICTs in general have the abilities to access, store and retrieve data, and provide tools for manual belabouring of information at an extent un-obtainable without applied ICTs. These technologies assist information sharing across time and space. ICTs have been applied for decades in support for business operations notably in sharing information on production, stocks, order processing and for general supply chain management. DMM-technologies further support media-rich communications and interactions for product-developments and business integration. These technologies have promising features for product-developments, individualisations, distributed virtual meetings, and for knowledge sharing.

Question arises to which kind of information is required by various business functions, when dialogue and communication is needed in knowledge-formation and how applied ICTs and DMM-technologies can satisfy these requirements.

Research Question 3:

How do ICTs and DMM-technologies impact business relations and industrial structuring of value chains?

Internationalisation of markets and dismantling of trade barriers have increased competitive pressures inside the industry. Responses to the increasing competitive pressures have included application of new technologies, production changes e.g. quality upgrading and individualisation, as well as restructuring of value chains e.g. outsourcing.

Competition is based on elements like technology, costs, quality and timing. New technologies not only alter production structures and costs, but also the information and communication-structures. Production- and distribution-costs are connected to batch sizes, scale of production, productivity, storage, location etc. Quality of products is based on both objective measures and on subjective perception of the offered items e.g. fashion, novelty, fitness, colours etc. Timing is essential in

optimising supply chains, minimise costs of over-stocking and minimising losses from being out of stocks.

Strategies of product alterations, branding and supply chain optimisations require new and more intensive modes of information-access and -exchange. Information has to be collected earlier and distributed throughout the value chains in order to ensure flexibility. Increasing volumes of data stem from altered production processes, from more and smaller batch productions and from individualisation. Information-levels also increase with the level of industrial specialisation and number of links in value chains. Competitive pressures and strategy changes put enhanced emphasis on the need for smooth information-processes and communications assisted by ICTs and DMM-technologies. The shared information is related to production and sales data like CAD-CAM files, e-mails and EDI-messages.

Competitive requirements of production flexibility and correct forecasting also mean that information should be managed and distributed speedily. Value chains that are able to satisfy these information- and communication-requirements have higher probability to succeed than others do. ICTs and DMM-technologies get applied in order to satisfy these needs and increasingly provide opportunities to share knowledge, for learning and value chain upgrading.

Technologies have the ability to restructure value chains, composition of national industry and international interactions. Value chains get restructured as firms specialise and transfer tasks to other firms, which lead to tighter interaction but also potentially to inclusion of new, specialised businesses. Incorporation of new specialised businesses relates partly to the improved matching abilities associated with higher information-levels and communication-abilities, and partly to the potential separation of information processing from actual physical belabouring. With the increasing abilities to transmit data the potentials to nullify geographical distances arise: industrial districts and national boundaries lose importance and internationalisation of production can prevail.

Questions mount on the specific requirements for information- and communication-abilities by different sectors and in different value chains. Different technologies get applied differently and support different functionalities, questions must relate to how the technologies impact value chain formations, interactions between businesses, internationalisation of production, and market operations.

Summary
Investigations of ICTs and DMM-technologies reveal evident support for information sharing, and accelerating abilities for distributed access to shared multimedia-files and for media-rich communications. Economic theories deal with some aspects of information sharing but give little attention to the qualitative aspects of information and the acts of communication. Thus, a more detailed analysis is required that deals with the commercial impacts from enhanced distributed communications. A string of research questions has been posed dealing with the theoretical understanding of communications, information and communication-requirements in the industry, and on the expected impacts from applied DMM-technologies on industrial organisation.

2.2. Information and Communications in Economics

This section offers a theoretical interpretation of information-needs by businesses of the industry. Through construction of a communication model that describes information- and communication-needs by businesses and by value chains, it becomes possible to offer a more detailed analysis of impacts from developments in ICTs and DMM-technologies on the industrial organisation.

As indicated in the research-questions it is possible to analyse information- and communication-processes and applied technologies from different perspectives. At the basic level it is necessary to understand the requirements by individual firms. Information- and communication-needs presented in the constructed model are associated with formation and organisation of knowledge. The commercial knowledge is expressed in production costs and organisation costs, which in turn are impacted by contracting issues. Contracting indeed presents the formalised economic linkage between businesses and thus deserves special attention.

At a more bird’s-eye level of analysis that encompasses industry-wide structures, the communication model encompasses information- and communication-flows in value chains. Industrial organisation of the textile and clothing industry is dominated by value chain structures and distributed production processes. This mode of production-organisation not only describes the sequence of product belabouring, but also indicates the information-access and -structure. It is assumed that information sharing is especially needed within distributed value chain structures, which relate to integrated logistics and production structures. ICTs provide tools for sharing information as well as for communicating and generating shared knowledge. Development of ICTs and DMM-technologies

shifts the boundaries for what can be transmitted and communicated through electronic networking, which impact the industrial organisation.

With distributed value chains the information-acquisition not only has to deal with market and product issues but also with behaviour of business partners: their motivations, skills, capabilities, trustworthiness etc. Economic success in highly fluctuating markets with continuously changing conditions requires that agents get informed swiftly to create knowledge on why (to produce, motivations), what (to produce), who (to contact and depend upon), how (to produce), where and when (to reach markets). These key-questions relate to both individual activities as to corporate activities, and impact both the production-costs and costs of organising value chains.

Construction of a communication model has to consider the fundamental information-requirements by businesses and the communicative aspects. A comprehensive model has to deal with the acquisitions of quantitative information as well as with the qualitative aspects mediated through communication. These issues are dealt with in the following sections. Before describing the information and communication model it is required to specify the applied terms and their economic relevance. Such a specification is offered below and is followed by an interpretation of knowledge and learning in economics.

Information and Communications

Different approaches can be applied in analysis of the role of information in economics. Following the neoclassical approach that information is omnipotent and for free and the arguments for incomplete information: information can generally be understood as a lubricant that matches supply with demand. Analysis at this level relates to information-access, costs and structures. Emphases have been put on the telecom and information sectors of society and how technological improvements diffuse into other industrial segments[48].

At the micro-level information is instead a required input for knowledge formation and economic decision-making. This form of analysis deals with information-content and how information gets transformed into workable knowledge i.e. information is an increment to knowledge:

> "Information has also been defined as disconnected and apparently random events, data, impressions, stimuli, and so forth which, if and when connected systematically by means

[48] Freeman, Christopher (1988): "Economic issues", in IEE Colloquium on 'Information Technology – Engineering the Future'", Digest No. 23, pp. 1-3.

> of perceived similarity/dissimilarity, contiguity, theory, story, history, model or otherwise, come to constitute knowledge or meaning." (Babe, 1995[49]).

Information is in this view much more than just product characteristics as it relates to all events that can have an impact on economic decision-making. Differences between information and knowledge consist of their contribution in the human mind in understanding of different issues: Raw data or facts are information when perceived, incomprehensible data is just noise. When information as collections of justified believes gets structured in the human mind it is transformed into knowledge[50&51].

Hence, it becomes possible to distinguish between information and communication. Information is the data, impressions etc. that is communicated through a media; communication is the act or process of information transfer, exchange, interpretation and comprehension. Essential attributes of the communication-processes are abilities to interact and pose questions about the mediated information. Communication is not only based on verbal, visual or textual information sharing; dialoguing implies a shared platform consisting of a common language and shared reference frame. As opposed to information sharing, the communication-processes allow for questioning and for elaboration on the frame of reference, which are complex structures to communicate. Media-rich communications such as face-to-face meetings are suitable for communication of such complex structures, as abilities to exchange information increase with the number media applied[52].

Received data and information sometimes have to be questioned and thus are acts of dialoguing and communications required. Simplistic information-exchanges may be suitable for most economic decision-making e.g. information on prices, orders, quantities, and dates. Indeed, these information-flows are the cornerstones for much business-to-business electronic commerce mediated through ICTs as EDI-messaging. However other types of information is also required for decision-making relating to more complex or subjective issues, which requires dialoguing. These communication-needs refer to production know-how, market analysis, trustworthiness etc.

Communications are dependent on cultural aspects, language-issues as well as technological structures. Whereas facts are relatively straightforward to formalise and to communicate, it is much

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[49] Babe, Robert (1995): "Communication and the Transformation of Economics", Westview Press, Oxford, p. 11.
[50] Polanyi, Michael (1983): "The Tacit Dimension", Peter Smith, Gloucester, USA, Chapter 1: "Tacit Knowing", pp. 1-25.
[51] Nonaka, Ikujiro (1998): "The Knowledge-Creating Company", in Harvard Business Review on Knowledge Management, pp. 21-45.
[52] Daft, Richard and Robert Lengel (1986): "Organisational Information Requirements, Media Richness and Structural Design", in Management Science, Vol. 32, 554-571.

more complex to communicate conceptual frameworks and subjective interpretations as they contain large amounts of non-formulated or tacit knowledge:

> "Tacit knowledge is highly personal. It is hard to formalise and, therefore, difficult to communicate to others. Or in the words of the philosopher Michael Polanyi, 'We can know more than we can tell'." (Nonaka, 1998[53]).

Smooth communication has to be based on a common language, and homogeneity of a language rests with a shared cultural base and shared habits of interactions[54]. Internationalisation and globalisation of society alters languages and the patterns of human interactions. Communications increasingly have to deal with frame of reference before facts and information can be exchanged. With the growing internationalisation applications of ICTs have to stress the communication-abilities i.e. the development of DMM-technologies.

Communication also holds a technological aspect relating to the information structure, applied technology and their compatibility. Technological compatibility of different types of hard- and software determines who can communicate electronically with whom. The continuing development and diversity of ICTs suggests that compatibility becomes a growing concern, but through growth of the Internet and especially the http protocol compatibility problems may diminish. Nevertheless, compatibility of different programmes and the competing standards remain a relevant issue for most existing ICT. At another level of standardisation communication-networks depend on structured data. Abilities to satisfy different standards in competing networks have direct influence on the business-processes and commercial possibilities[55]. However, with transformation of the highly structured EDI-messaging onto the http platform, some of the embedded restraints from structured data exchange may be avoided.

Despite abilities to communicate, knowledge in itself might be of little relevance to the business if it cannot be retrieved and applied for business activity. Knowledge management as the process or practice of creating and sharing of knowledge is an essential element of business organisations[56]. Knowledge management is essential as an act or process that enables businesses to collect and retrieve

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[53] Op cit. Nonaka (1998), p. 27.
[54] Rullani, Enzo & Antonello Zanfei (1988): "Area Networks: Telematic Connections in a traditional Textile District", in Cristiano Antonelli (ed.): "New Information Technology and Industrial Change", Kluwer Academic Publishers, London, pp. 97-113.
[55] Brousseau, Eric (1994): "EDI and inter-firm relationships: towards a standardisation of coordination processes?", in Information Policy and Economics, Vol. 6, pp. 319-347.
[56] Scarbrough, Harry et al. (1999): "Knowledge Management: A Literature Review", in Issues in People Management, Leicester University, pp. 1-80.

data and learn form past experiences. Learning processes are furthermore the basis for generating core competencies and in directing innovative activities[57]. Indeed, learning mechanisms stem from the feedback mechanisms between experience and competence, and learning may then be viewed as the cumulative development of skills and knowledge[58].

Acts of Communications

Communications are highly subjective processes that relate to objective content, social structures and subjective interpretations. Modernist thinking since Descartes and Kant has emphasised the role of the subject i.e. human senses and individual perception in interpreting the object world[59&60]. As interpretation of the social and object world is based on human subjective experiences and perceptions, the knowledge of the object world has to be based on the historicity (time and space) of the spectator as well as personal contingencies. To disentangle these contingent communications we have to question the very basis for communication i.e. the frame of reference or worldview.

Communicative action to Habermas is the process of arguing and responding in dialogues between individuals, and covers both the content of arguments as well as the basis for the statements[61]. Communicative action encompasses the processes through which actors seek to establish an agreement, and agreements both concern statements and their basis. Communication deals with the three possible levels or worlds that we can possibly have knowledge of: the subjective, the social and the objective worlds:

> "In communicative action participants may implicitly or explicitly raise the substantive and real validity claims of proportional truth or efficacy (objective world), normative correctness or rightness (social world), and sincerity or authenticity (subjective world)... Validity claims raised in these forms of action relate to the three worlds of which people relate which in turn link to three relations contained in the concept of communicative rationality. These are: first, the relation of a knowing person to an objective world of events or facts; second, the relation to a social world of an acting, practical person entwined in interaction with others in a specific setting or community of practice; and finally, the relation of a suffering, passionate and emotional human being to its own

[57] Andreu, Rafael & Claudio, Ciborra (1995): "Organisational learning and core capabilities development: the role of IT", in Strategic Information Systems, Vol. 5, pp. 111-127.
[58] Levinthal, Daniel (1996): "Learning and Schumpeterian Dynamics", in Giovanni Dosi et al (eds.): "Organisation and Strategy in the Evolution of the Enterprise", MacMillan, Basingstoke, pp. 27-41.
[59] Somerville, Ian (1999): " Agency versus identity: actor-network theory meets public relations", in Corporate Communications, Vol. 4, pp. 6-13.
[60] Gulddal, J & M Møller (eds.) (1999): "Introduktion til hermeneutik – en antologi om forståelse", Gyldendal, Copenhagen, Introduction on the ideas of Heidegger.
[61] Nørager, Troles (1993): "System og livsverden: Jürgen Habermas' konstruktion af det moderne", ANIS, Copenhagen, Introduction, pp. 10-32.

> internal nature, to its own subjectivity and to the subjectivity of others." (O'Donnell, 2000[62]).

Interaction and communication between individuals let it be within or between organisations, have to establish recognition of the sincerity or authenticity of the opposing party. Through communicative activities the dialoguing parties will question rationality of reasoning and establish the truthfulness or trustworthiness of the other party. An objective of this communication is if possible to construct a shared worldview. Key elements of generating shared worldviews are identification of the authenticity and motivation of the other, and established correctness of value systems.

Communications in Economics

An essential part of the new or post-modern economy is that it is insufficient just to optimise production processes through mass-production structures, indeed businesses have to invent new products, services and organisational structures to satisfy increasingly volatile demand conditions[63,64&65]. In this economical paradigm denoted as the knowledge or learning economy successful businesses do not only depend on optimised internal production processes, they also depend on accurate knowledge about market conditions, correct demand forecasting and optimised value chain structures. Businesses specialise their activities and outsource the others to trusted business partners[66]: trust, as the mutual confidence that the other party will not exploit others' vulnerability, is a part of social life and communicated through interpretation of common norms and articulation of worldviews[67]. Viable integration strategies relate to optimising feedback processes, improve organisational routines and capabilities embedded in technological and human resources[68&69]. A key element in business strategies is to acquire direct and reliable information that provides fast tools for demand forecasting and product innovations. Value chain structures and networking are constructed in order to reap specialisation advantages required in ever growing competitive conditions. Information

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[62] O'Donnell, David (2000): "Intellectual capital: a Habermasian introduction", in Journal of Intellectual Capital, Vol. 1, pp. 187-200, p. 193.
[63] Piore, Michael & Charles Sabel (1984): "The Second Industrial Divide", Basic Books, USA.
[64] Best, Michael (1996): "The New Competition: Institutions of industrial restructuring", Polity Press, London, Introduction, pp. 1-26.
[65] Amin, Ash (ed.) (1999): "Post-Fordism: a Reader", Blackwell, Oxford.
[66] Holland, Christopher & Geoff Lockett (1998): "Business Trust and the Formation of Virtual Organisations", in Proceedings at the 31st Annual Hawaii International Conference on Systems Sciences, pp. 602-610.
[67] Sabel, Charles (1992): "Studied trust: Building new forms of co-operation in a volatile economy", in Frank Pyke & Werner Sengenberger (eds.): "Industrial districts and local economic regeneration", International Institute for Labour Studies, Geneva, pp. 215-250.
[68] Op cit. Andreu & Ciborra (1995).
[69] Ciborra, Claudio (1992): "Innovation, Networks and Organisational Learning", in Cristiano Antonelli (ed.): "The Economics of Information Networks", Elsevier Science Publishers, The Netherlands, pp. 91-102.

on sales performances and logistics entangle the value chains, just as communication-structures enable shared knowledge on technological developments and product innovations.

Theoretical contributions on communication in economics have tended to focus on the learning processes and knowledge-formation, but it should also be recognised that communication-processes have direct implications for contracting issues too. Communication impacts the knowledge-formation processes, impacts the individual bounds to rationality and degrees of incomplete information. To the extent that knowledge is partially tacit and product specifications are based on dialogues, communications are needed in the contracting processes. Personal communications are also needed for expressing shared worldviews, for mediating trustworthiness and for risk-evaluation.

Communication-processes have been translated into an economic framework, where constructions of shared worldviews are prerequisite for subsequent contracting procedures[70]. Economic communication to Bonatti depends on a shared worldview that entails common understanding of the problem at hand and agreed value systems, which ensures that trust is expected and communication eased. Following processes deals with determination of what to produce. Identification of exactly what to produce has to be based on communication-processes as the problem-owner lack knowledge about what is technically possible and wanted, and solution-providers who have the technical skills do not know exactly what is wanted. Communications hence encompass some presentation of ideas by the problem-owner, which get interpreted by the solution-providers that offer some sketching of possible solutions.

Communication-processes hence firstly establish a foundation for further communication based on shared worldviews and secondly lead to specifications of products. Dialoguing is required in the processes of specifying products, as none of the involved parties know what the result should be or how it eventually turns out. The problem-owners only have vague ideas of what to produce, which is only partially expressible and partly tacit[71]. Substantial parts of our knowledge are unconscious or hidden and thus called tacit knowledge; “we know more than we can formulate”. The solution-providers receive the messages one these ideas, which gets interpreted via their special knowledge leading to proposals for a solution. The proposed dialogues between problem-owners and solution-providers will not only lead to exchanges of experiences and know-how, but also generate understandings of the problems and possible solutions in the minds of both parties. Knowledge is

[70] Interpretation of the analyses, thoughts and ideas of Mario Bonatti is based on dialogues, seminar sessions and on his unpublished working paper: “RoadMap to Set-up an Interactive Group for implementing a Virtual Environment supporting Value Systems of Quality Artisanal Chesses”, (2000).
[71] Op cit. Polanyi (1983).

created and made explicit as these hidden ideas are transformed into formulation of requirement specifications.

Establishment of shared worldviews seems of little interest in other contributions on communication-processes and formation knowledge[72&73]. Especially to the extent that knowledge-creation is founded in communication inside organisational boundaries, the focus instead relates to how knowledge can be shared through four forms of exchanges: 1) Socialisation i.e. socialising and sharing of experiences leading to knowledge through "shared mental models and technical skills". This process transmits tacit knowledge of one to tacit knowledge of another. 2) Externalisation is when tacit knowledge gets articulated into explicit concepts e.g. through writings. 3) Combination encompasses processes where explicit knowledge gets systemised into other explicit knowledge systems. 4) Internalisation is when explicit knowledge gets transformed back into tacit knowledge through learning by doing. Adopting this conceptualisation communication-process is particularly important in the processes of socialisation and of externalisation. Socialisation creates and transmits shared tacit knowledge as agents communicate, adopt similar language and shared "mental models". Socialisation somehow resembles the formation of shared worldviews. Externalisation as the process of articulating tacit knowledge resembles the proposed processes of formulating product specifications.

Product specifications are only reached through repetitive dialoguing and through application of tools for presentation of the sketched proposals. Applications of ICTs seem especially promising in respect to drafting and prototyping processes. CAD-technologies have the potential to make virtual presentations of drafted ideas and to make easy alterations. Further advantages relate to the distributed properties through electronic networks, and for time and cost savings through reducing the needs for physical prototypes. Prerequisite establishments of worldviews and other social interactions have been mediated through other communication-tools such as telephones. However, these processes are often too complex and calls for media-rich communications: face-to-face meetings or virtual meetings enabled through applied DMM-technologies[74].

[72] Nonaka, Ikujiro et al. (1996): "A theory of organizational knowledge creation", in International Journal of Technology Management, Vol. 11, pp. 833-845.
[73] Op cit. Nonaka (1998).
[74] Op cit: Daft & Lengel (1986).

Knowledge in Economics

Knowledge relates to either practical knowledge of production i.e. know-how or to the more intellectual knowledge-forms of know-what[75]. Obviously attentions in economic theory have been given to the act of information processing and knowledge-formation related to the production activities i.e. know-how. Attention has been given to technology and mechanisation, scientific management, learning organisation etc. with the emphasis of improving business operations. Know-what on the other hand relates to more descriptive empirical knowledge.

Operational knowledge has been incorporated into the economic sphere through different approaches. One approach, evolutionary economic theories suggest that organisational practices and routines develop through feedback loops and learning mechanisms leading to knowledge-formation[76]. Another approach, the learning economy suggests that humans interact in order to learn and generate knowledge, which are requisite to decision-making and innovative activities. Knowledge in this view hence relates more to deposits of collected information, which contrasts the evolutionary focus on organisational routines.

In the evolutionary approach routines determine the economic activities, and feedback processes enable collection of information on the economic performances. Collection of information that is structured through feedback loops relates various aspects like technical innovations, product alterations, market and organisational issues, and determines the knowledge-formation of the firm. Organisational routines are continuously reproduced and attempted improved through mutations or innovations. Through the feedback mechanisms businesses acquire information about the viability and suitability of their innovative activities. However, due to human limitations incomplete and misunderstood information potentially flaw the knowledge-formation and learning processes:

> "Economic change is caused by interaction between learning processes in firms and selection forces. This means that learning processes sometimes lead to correct information about the internal-external dynamics of selection and sometimes not." (McKelvey, 1998[77]).

In this routine based approach communication is related to information feedback mechanisms. Information from environments led to knowledge when the received data gets related to organisational

[75] Op cit. Polanyi (1983).
[76] Nelson, Richard & Sidney Winter (1982): "An Evolutionary Theory of Economic Change", Harvard University Press.
[77] McKelvey, Maureen (1998): "Evolutionary innovations: learning, entrepreneurship and the dynamics of the firm", in Journal of Evolutionary Economics, Vol. 8, pp. 157-175, quote from pp.161-2.

routines. Knowledge-formation hence relates more to feedback than to accumulation and to dialoguing.

In the learning economy knowledge is required in order to innovate products, product developments and in decision-making[78,79,80&81]. Knowledge is the stock of information relevant to economic decision-making acquired through learning processes. Both learning and knowledge form cornerstones for innovation processes that are essential to economic activity, and have been divided into four categories. Firstly, there is knowledge about actual events and facts i.e. "know-what". Secondly, there is "know-why", which is the "scientific knowledge of principles and laws of motion in nature, in the human mind and in society."[82]. Thirdly, there exists knowledge on the social environment called "know-who" i.e. knowledge on who knows what and can do what. Finally, there is knowledge on how to do things; "know-how", which is essential for any production activity. This fourfold division of knowledge offers a more detailed discussion of communication than that of Polanyi, who only applies a dual distinction between practical and intellectual knowledge.

Emphasis in the learning economy of Lundvall et al. is not on allocation of scarce resources but on how to innovate and learn in order to apply new skills and enhance utilisation of existing resources:

> "Learning to make new things for new markets in new ways is the key to economic success in the modern economy… in principle, innovation is a ubiquitous phenomenon, and the learning capability of economies is more important than their capacity efficiently to allocate some given scare resources." (Lundvall, 1996[83]).

Innovative abilities, it is further argued, hinge on the businesses' abilities to communicate and interact with other businesses. A strong emphasis is made on learning process i.e. the interactive attributes of learning and knowledge-formation. In essence learning is an interactive process, agents interact and exchange information and experiences i.e. learning is constituted in the personal relations and actions.

Special kinds of communication-structures are required in order to connect the cost information from markets and organisational information from hierarchies. Nonaka has paid much attention to

[78] Lundvall, Bengt-Åke & Björn Johnson (1994): "The Learning Economy", in Journal of Industry Studies, Vol. 1, pp. 23-42.
[79] Lundvall, Bengt-Åke (ed.) (1995): "National Systems of Innovation – Towards a Theory of Innovation and Interactive Learning", Pinter, London, Introduction, pp. 1-19.
[80] Lundvall, Bengt-Åke (1996): "National Systems of Innovation and Input-Output Analysis", in Christian DeBresson (ed.): "Economic Interdependence and Innovative Activity", Edward Elgar, UK, 356-363.
[81] Lundvall, Bengt-Åke (1998): "Why Study National Systems and National Styles of Innovation?", in Technology Analysis & Strategic Management, Vol. 10, pp. 407-421.
[82] Op. cit. Lundvall & Johnson (1994), p. 27.
[83] Op cit. Lundvall (1996), p. 357-8.

transformation processes of knowledge inside organisations[84], but he disregards interorganisational communication and learning i.e. disregarding markets. Lundvall on the other hand recognises the existence of both dimensions, but perceives pure hierarchies too structured and restricting and pure markets as too flat, offering too simplistic information-exchanges in both forms. The optimal environments for communication, interaction and learning are instead the organised markets or information networks. In this view information networks offer a medium for interacting and learning about needs, wants and possibilities required for product innovations. Networking and alliances are thus generated to access information and to form essential knowledge, which contrasts other approaches to alliances to gain strategic access possibilities[85] or to leapfrog technological or organisational barriers and boost developments[86].

Knowledge-formation in the learning economy not only relates to what and how to produce but also to social and subjective issues of who to work with. Knowledge of who to work with is important and knowledge management on past experiences and co-operation information are required to know who can do what. The learning processes are assumed necessary for businesses to survive in the learning economy and thus assumed beneficial and relevant to all irrespective of business strategies. Businesses have to exchange information and experiences but very little recognition is given to choices of who to work with and the identification processes. Learning economy stresses that information is essential and that skills are important tools to, but has not much interest in processes that identify partners.

Summary

This section has offered an interpretation of information, communication and knowledge from a theoretical perspective. Information relates to accessing and structuring data, and communications in addition encompass activities of perceiving and understanding information. Communication-structures are based on dialoguing where the actors can question the information and elaborate to enhance understanding and shared knowledge. Knowledge is highly personal, somewhat tacit and calls for media-rich communication-structures in order to express subjective, objective and social perspectives.

Economic theories stress the quantitative aspects of information, and deal only slightly with qualitative aspects of communication. Roles of communication in economics relate to knowledge-formation, learning processes, and product developments, but processes of personal communications of

[84] Op cit. Nonaka (1998) and Nonaka et al. (1996).
[85] Porter, Michael (1980): "Competitive Strategy – Techniques for Analysing Industries and Competitors", Free Press, New York.
[86] Op cit. Ciborra (1992).

worldviews should also be considered. Key elements of generating shared worldviews are identification of the authenticity and motivation of others, and establishing correctness of value systems. Translated to an economic sphere: communication-processes firstly have to establish a foundation for further communication based on shared worldviews, which secondly lead to specifications of products.

2.3. The Communication Model

Economic theories provide good analytical tools for investigating the roles of information on economic activity, less clear are how to comprehend interactivity and communication-abilities. In the previous section is was disclosed that communications as well as information sharing have impact on the economic activities as agents can communicate worldviews, evaluate skills and trustworthiness and interact in product developments. Hence, it is required to present an analytical structure that combines the information, interactivity and communication in an economic environment. Theoretical contributions outlined above contribute the essential analytical tools for analysing communicative structures in industry and provide some important tools for construction of a communication model. The core of the communication model constructed in this section is based on the four categories of knowledge from the learning economy, communicative activity on worldviews and product specifications, contracting issues and value chain structures. The following paragraphs are divided into a section on the micro-foundation of information needs and knowledge-processes. A section follows this on transacting processes pointing to communication-structures that constitute the business relations at the messo-level. Finally, there is a section on the macro-perspective and value chain structuring.

Knowledge Forms

At the micro level of information needs and communication-processes, it is necessary to stress the bounded rationality of agents and importance of information exchanges and communications in learning and knowledge-formation. Information and communication are necessary components of forming, evaluating and innovating organisational routines and in accumulating knowledge on how to do things, whom to work with etc. Information is related to data that is easy to interpret and comprehend, and relates to many aspects of production organisation. In addition, communications have distinct functions in exchanging and obtaining more complex knowledge.

Acquisition of information and communication relates to the subjective, objective and social worlds, and the more complex or uncertain the context, the more the need for media-rich communication and dialoguing[87]. Successful dialogues both within and between businesses presuppose a common language and shared worldviews, which involves communication of social structures and subjective perception:

> "In a world where agents differ in their perceptions of the environment, and where communication, acquisition of information and computation are limited and costly, coordination can only be achieved by means of the definition of a common set of rules, codes and languages, which are well understood and shared by all the members of the organisation involved in a certain interaction. Routines, rules, procedures, standards, etc. become then central in the conceptual framework." (Cohendent et al, 1996[88]).

After establishment of motivations and value systems i.e. shared worldview, the agents have the framework to discuss objective matters without further considerations with intentions and trustworthiness of the other. Communicative actions between agents are essential as some of our knowledge is tacit and requires dialoguing processes for it to become explicit. In addition to transforming tacit knowledge into explicit knowledge, we may also learn from accessing information about new production techniques and methods to solve problems. Knowledge-formation and learning abilities are constituted in the individual capacities and organisational routines that may be more or less successful in generating feedback loops between innovative activities and the knowledge-creation[89].

Four areas of knowledge are decisive for economic performances and strategic choices[90&91]: facts and events (know-what), principles and laws in nature, human mind and society (know-why), social structures (know-who) and on production (know-how). The know-why relates to the subjective world, and in combination with the social structures expressed in know-who constitutes foundation for worldviews. Worldviews are complex structures that require face-to-face meetings or application of media-rich ICTs to communicate i.e. DMM-technologies. Know-what and know-how are also complex issues that are related to tacit dimensions of problem owners and solution providers. Intensive communication-structures are required at least in the developmental phases of product- or routine-innovations, after which they may be subjected to simplistic information-processes, mediated e.g. through barcoding and EDI-messages.

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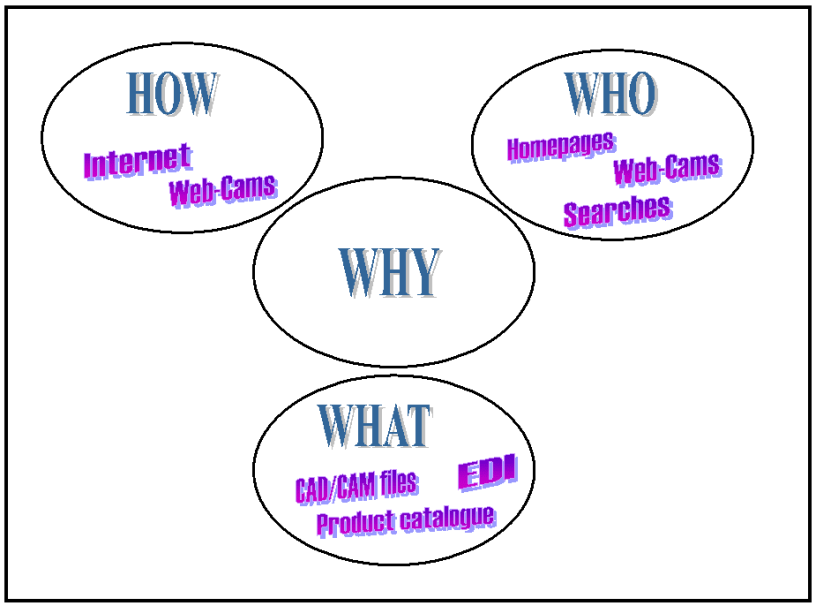
[87] Op cit: Daft & Lengel (1986).
[88] Cohendent, Patrick et al (1998): "Theory of the firm in an evolutionary perspective", Working paper, pp. 1-28, p.6.
[89] Op cit: Simon (1995).
[90] Op cit: Lundvall & Johnson (1994).
[91] Johnston, Russell & Michael Vitale (1988): "Creating Competitive Advantage With Interorganizational Information Systems", in MIS Quarterly, Vol. 12, pp.153-165.

The four forms of knowledge centred on know-why are presented in the figure below. In this model emphasis is put on the internal motivation i.e. knowledge of why, which is an essential component of subjective perceptions and worldviews. Through this knowledge the individual is enabled to communicate and construct shared worldviews with others, and hence to determine who to co-operate with (know-who), the requirement specifications and what to produce (know-what) and how to produce and organise production (know-how). These three areas of knowledge: who, how and what are thought to be highly interrelated, as determination of what to produce cannot be accomplished without knowledge of who to co-operate with. Knowledge on who to work with depends on the knowledge on how to produce. And finally, know-how is of little use unless in connection with knowledge of exactly what to produce.

Figure 2.1: Business knowledge and applied DMM-technologies



Different ICTs and DMM-technologies assist formations of the knowledge-categories. Establishment of what to produce is first and foremost supported by interactive multimedia files that display products and enable shared product developments. Other supportive technologies include online market and fashion analyses, e-mail interactivity and EDI-messaging on sales, stocks, orders and production. Knowledge-formation on who to work with is supported by online searches, data on past events and reputation, displays of skills and personalised virtual meetings that establish shared worldviews and trustworthiness. How to produce is also dependent on information sharing and communications, as

feedback structures are essential to the learning processes: feedback is enabled through virtual meetings, monitoring, EDI-based reports and emails.

Know-Why

Knowledge of why is the starting point for economic action in this model. To understand individual economic activity one must consider why agents perform particular actions, and what shapes their motivations. Motivations are simply suggested uniform in neoclassical theory as agents either profit maximises or utility maximises. Know-why as the "laws of motions in nature and society"[92] has a tendency to emphasis processes at the expense of individual motivations. The diversity of human actions should be found in their diverse internal motivations. Motivations are thought fundamentally connected with worldviews as the former influences the way the world is viewed and vice versa.

Just as there are a large variety of firms in industry, there exist a large variety of individual and business motivations. Motivations shape conditions for economic actions, which in turn lead to some results and feedback processes that in turn may correspond to the defined goals and motivations. It is believed that motivations are tightly connected to function and position in value chains: Designers may be motivated by artistic values, reputation, impact on fashions etc. as well as by profits. To the extent they seek artistic or other value instead of economic values they will design extreme products that are not meant for use or sales. Manufacturers and textile producers are thought motivated primarily by economic values and only secondarily with artistic ones, nevertheless they will have interests in creating good quality products that yields high satisfaction with the customers. These motivations may result in production processes that respect some cost considerations, but equally emphasis quality and timing issues. The retail link is though positioned in-between these two extremes as they both deal with artistic values and economic values. Their motivations would rest with coherent dressing for customers, customer satisfaction and providing value for money. This could result in displays of large arrays of products that satisfy the variety of individualistic needs and tastes of customers.

Expressions of individual motivations are related to skills i.e. the more skilled a person or business the wider the opportunities on what to do and the more relevant to determine motivations. Know-why is in this model emphasising individual motivations and hence ICTs and DMM-technologies get applied for communicating skills, personal perceptions and worldviews.

[92] Op cit: Lundvall & Johnson (1994).

Know-Who

Knowledge of who to work and co-operate with and who to outsource functions to seems crucial to successful value chain structures. Competitive strategies are centred on provision of right quality clothing at the right time and price. In order to obtain these objectives, businesses have to depend on others for information-acquisition and for specialised production services as well as the ability and willingness of others to provide the required goods and services. Identification of such firms contains twofold processes of searching for potential partners and subsequently to negotiate terms and conditions. Searching for business partners is constrained by applied information channels and geographical focus, which historically has been dominated by proximity e.g. within districts. Search-conditions include cost, quality and availability issues, and negotiations relate to construction of shared worldviews and product specifications. Exchanges of worldviews are based on communication of motivations i.e. know-why and value systems, which indicates whether a business is worthy of trust. Industrial district have an appealing attribute in being geographically confined and based on personal or even family ties, which vouch for some minimum levels of shared worldview and trust. Communication of worldviews is eased by media-rich structures, shared cultural base, and by a common language.

Another important element in establishing whom to work with relates to establishing control and monitoring mechanisms. Establishment of shared worldviews promotes mutual understandings of division of tasks, incentives, rewards and trust, but the process may be somewhat erroneous and unwillingly businesses can end up with unwanted business partners. Monitoring and economic motivations may prevent that these relations develop uncontrolled[93&94].

Applications of ICTs and DMM-technologies have become increasingly useful e.g. in generating Internet-based searching facilities, business-to-business marketplaces, and homepages to display products and skills. Further functionality includes Internet-based accesses to shared databases on quality, costs, reputations etc. And the communicative abilities provided by web-cams and videoconferencing enable that shared worldviews and trustworthiness be established.

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[93] Alchain, Armen & Harold Demsetz (1972): "Production, Information Cost, and Economic Organisation", in American Economic Review, Vol. 62, pp. 777-795.

[94] Foss, Nicolai et al (1998): "The Theory of the Firm", available at www.cbs.dk/departments/finance/publikationer available June 2000, pp. 1-21.

Know-What

Successful economic actions hinge on deciding what to do, but that is not always easily determined. In some cases, the individual only possesses a partial knowledge about what to produce and thus have to acquire further information and knowledge from others. This stipulates a need to communicate in order to solve technical problems and determine requirement specifications. Communications and dialogues enable problem-owners to present ideas to the solution-providers that in turn sketch possible solutions. These forms of interaction enable tacit knowledge to become explicit just as agents may acquire knowledge and learn about new processes and techniques. Besides the communication needed in the development processes, the actors need market information and trend analyses to forecast market demands. This kind of information relates both to subjective analysis and to objective statements such as recorded sales data. As part of this information is easily codified it also gets easily distributed through structured data processes.

More specific, determination of quantitative aspects of market demands hinges on acquisition of accurate sales data and received order, which can be communicated through barcoded items, scanners, and EDI-messages. From reported sales data and market analyses the manufacturers are able to construct demand-forecasts and decide what to produce and when to reach markets, which get qualified through comminations with specialist traders and retailers. Qualitative aspects of products i.e. product developments are less tangible. Manufacturers require services of designers to develop the wanted designs, likewise retailers depend on inputs from consumers to determine their preferences, and on interactions with manufacturers to communicate market needs. Mediations of product designs are to a large extent enabled through physical products e.g. prototypes, but digitised media as CAD/CAM-files and virtual catalogues are also applicable. Latest trends include direct Internet-based interactions between final customers, designers and manufacturers, which allows for expression of individual preferences and sizes.

Know-How

Available resources, technology, personnel and skills are not static, nor is the knowledge on how to organise resources. Businesses structure their production processes around routine-based activities that have developed through experience as an efficient way to do things, but they may continuously seek to change and improve existing routines[95]. Experiments and purposeful innovative activities seek to alter performances, which is reflected in altered market position. The altered routines are reflected in

[95] Op cit: Nelson & Winter (1982).

markets, which in turn generate a feedback about the effects of innovations. Generation of feedback mechanisms enhances the businesses' knowledge of the viability of developed routines. Efficient channels for these feedback processes are no guarantee against misunderstood information or random events that leads to error-ridden interpretations, but they are essential for businesses in their decision-making on specialisation processes, development of core competencies and strategic choices[96].

Technological know-how and specialisation have determined how different businesses have chosen to act. Technological changes have been evident within the textile and clothing industry through decades especially within textile fibres and processing techniques, and least evident within sewing processes. Technological changes have motivated businesses to invest in dedicated technologies, specialise processes and obtain competitive advantages through applying ICTs and/or mass-producing structures. ICTs have played key roles in development of smooth international value chains. Exchanges of data and production know-how have marked successful structures e.g. through CAD/CAM-files and EDI-messages. ICTs also facilitate acquisition of new services, and information on and access to new technologies.

Transacting

Contracting, which is an essential element of transacting is the link that combines the businesses in different value chains. Transacting include a wide set of activities of which contract specifications and negotiations are only a few. Prior processes include searching procedures, and following ones encompasses monitoring and finances. A range of contributions has dealt with the transacting issues notably in transaction cost analysis, more recent studies analyse more specifically the steps of contractual relations. Through the transaction cost analysis it has been showed how hierarchical relations differ from market relations through eased search structures and longer duration of less specified contracts[97], or by lower opportunism and lesser restraints on the bounded rationality[98]. These contributions have emphasised the transaction costs associated with competing organisational structures, but not indicated anything about whom to contract with, likewise they do not offer ties to the entrepreneurial inability in specifying products.

[96] Dosi, Giovanni & Richard Nelson (1994): "An introduction to evolutionary theories in economics", in Journal of Evolutionary Economics, Vol. 4, pp. 153-172.
[97] Coase, Ronald (1937): "The nature of the firm", in Putterman, Louis (ed.) (1986): "The economic nature of the firm", Cambridge University Press, pp. 72-85.
[98] Williamson, Oliver (1975): "Markets and Hierarchies: Analysis and Antitrust Implications", Collier Macmillan Publishers, London.

In the more recent analyses the transacting steps have been divided into several categories depending on the level of detail in the applied analysis. Despite differences on the number of transacting steps, some agreement seems evident for the contracting activities: firstly there is a searching procedure, followed by negotiations and settlements, and finally some post-contracting activities. Investigations of personal relations in business-to-business interactivity provide some of the most detailed levels of transaction analyses e.g. six steps of transacting: search for partner, specify agreement, enforce contract, handle finances, specify items and advertise, of which the last two should be conducted early in the contracting phase[99]. Analysis shows that personalised relationships are legio for solving problems and reducing governance costs, but does not say much about the order of supplier identification and product specifications.

Other approaches emphasise other interactions and apply fewer transacting steps e.g. five-steps of information and material flows between buyers and suppliers in analysis of electronic commerce[100]. From a buyers' perspective these steps are: Identification of needs through analysing information, find sources trough information, arrange contractual terms through influence, purchase through money, and use, maintain and dispose through information. In this interpretation identifications of needs precede finding a source i.e. solution-provider, which hence assumes that the agent is capable of specifying products without interaction with the source. In interesting analyses on applied ICTs transacting has been reduced to 4 processes i.e. information, negotiation, settlement and after-sales processes[101]. Transacting starts with the information stage where potential sources are identified, which is followed by a consensus-generating step of negotiations i.e. shared worldview. Negotiations are dealing almost exclusively with financial terms and conditions instead of considerations on product specifications.

Later contributions deal with perspectives of intermediation services[102]. Analyses just offer three steps of transacting based on information and search, negotiation and contracting, and settlements. Like the other analyses the initial transacting stages are though to relate to identification of products and suppliers, which is only possible through knowledge of what to acquire. Negotiations of delivery and

[99] Kraut, Robert et al. (1998): "Coordination and Virtualisation: The Role of Electronic Networks and Personal Relationships", in Journal of Computer-Mediated Communication, Vol. 3, No. 4, pp. 1-34.
[100] Nissen, Mark (1998): "The Commerce Model for Electronic Redesign", in Journal of Internet Purchasing, available at www.arraydev.com/commerce/JIP.
[101] Gebauer, Judith & Arno Scharl (1999): "Between Flexibility and Automation: An Evaluation of Web Technology from a Business Process Perspective", in Journal of Computer-Mediated Communication, Vol. 5, No. 2, pp. 1-24.
[102] Schmitz, Stefan (2000): "The Effects of Electronic Commerce on the Structure of Intermediation", in Journal of Computer-Mediated Communication, Vol. 5, No. 3, pp. 1-22

reward conditions for the pre-specified items, and finally some settlement steps of monitoring, delivery and payments hence follow this process.

These considerations have led to construction of a three-tired transaction process much like the general approach from above, however with a different emphasis on contents. Like the transacting stages of Kraut et al. it must be stressed that contracting activities must include specifications of products. Whereas most of the contributions assume predefined knowledge about what to produce and acquire, this assumption seems unrealistic for product developments under bounded rationality. Hence, the relevant transaction steps for this analysis are a pre-contractual, a contractual, and a post-contractual phase.

Table 2.1: Transaction stages

	Means	**Achievements**	**Knowledge-formation**
Pre-contractual	Personal relations, searches, displayed skills, past experiences	Worldviews & trust	Know-why & know-who
Contractual	Present ideas, sketch solutions, market & fashion analyses	Product specifications, conditions & reward systems	Know-what
Post-contractual	Monitoring, after-sales services & data	Productions, learning, skills & evaluations	Know-how

In the pre-contractual stage, businesses search for suppliers based on personal relations, historic events, accessible information etc. A key issue is that searches are based on acquisition of skills and services as well as on specified products: pre-contract information-processes include searches for products, skills, reputations, capabilities etc. of other businesses. Subsequently, in the pre-contracting phase the businesses communicate shared worldviews, which are required for creating trust, governance structures and developmental processes. In the contractual stage, firms outline ideas and sketch solutions through repetitive processes leading to the product specifications. Further aspects of the contractual phase are settlements of conditions and reward structures. And in the final post-contractual stage, businesses interact through monitoring, exchange of experiences, interpretations, management and production information etc. until the contract end.

Value Chain Structures

Industrial reorganisation is analysed through investigations of value chains, which also constitute the most aggregated level of this communication model. Constructions of value chains are based on the

micro-level needs for information and knowledge-formation processes, and the messo-level contractual conditions outlined above. The analysis of value chains derives from Porters investigation of competitive advantages of nations and industries[103&104]. Within this analytical programme it gets possible to split up the operational functions of businesses and rearrange them in chain structures. Restructuring of chain structures leads to competitive advantages as the value chains extract economics of scale, specialisation gains, access to special resources etc. In this kind of analysis it is assumed that decision-makers are fully informed about their competitive situation, and respond proactively and rationally through formation of business alliances.

Typically, presentations of value chains focus on functionally and spatially separated steps. Within each of the production steps, the materials or services get belaboured, which induce a higher level of value to the customer. However, such interpretation of value chain structures is too simplistic, as it does not account for shared knowledge-formations in product developments and needs for feedback in order to learn. Viability of value chains requires extensive information-flows, both up- and down-stream, which is only given little attention in the simplistic chain structures. Transmissions of information down-stream relate to material-flows and processes e.g. to process data, quality and quantity data, distribution etc. Extensive information is also communicated up-stream such as market demands, sales data, trend analysis, and customer specifications. Communications within industrial value chains, not only encompass one or two-way processes between two connected steps, indeed communication is performed within networking structures where information from one node is distributed and shared with all other nodes.

Communications within value chains encompass interactions between major players. Manufacturers are often the owners of production processes and require intensive communications with retailers on customer demands and sales strategies, fashion and market analyses for demand forecasting, just as need to receive orders and deliver goods. They also need to communicate with their subcontractors on how to organise productions, what is possible to produce, qualities and costs etc., alongside production process data and distribution information. Communications with designers are based on what to produce and promote, what will the future trends be, just as they exchange design data, patterns, colour codes etc. ICTs and DMM-technologies support information sharing and interactivity, and for provision of trend and market analyses from distributed sources.

[103] Op cit: Porter (1980).
[104] Porter, Michael (1990): “The Competitive Advantages of Nations”, Free Press, New York.

An important aspect of industrial developments has been the tighter relation between the involved businesses within value chains. Product developers interact more with producers and subcontractors, just as retailers and customers get integrated in information networks. Tighter interactions are required for quicker provisions, larger flexibility, responsiveness to changed demands, learning, and upgrading quality levels. Unsaid to this perspective is that businesses share both standard and strategic information, and that they perceive other businesses in the value chain as partners more than competitors. Business interactions within value chains are hence perceived as win-win situations, whereas extra-chain relations are much more competitive.

Analyses on the impact from ICTs on value chain structures have highlighted information processing and dealt with attributes of browsing and identification of new business partners. It has been argued that applications of ICTs will lead to standardised information, reduced information costs and hence improved abilities to shop around for cheapest supply. Electronic markets will become the optimal organisational structure due to improved browsing effects[105] and economy of scale in information gathering and transacting, which reduce transaction costs[106]. It has however also been argued that applications of ICTs i.e. the distributed interactivity, first and foremost enhance integration of businesses i.e. leads to electronic hierarchies instead of electronic markets[107]. The integrating aspects relate partly to the composition of ICTs themselves i.e. incorporation of shared and somewhat proprietary technology standards increases switching costs and binds business partners[108&109]. And partly the integration is governed by extraordinary information-flows, which facilitates speedier operations and enhance operational flexibility[110&111], just as the improved quality of information lead to exchanges of know-how and improved quality of productions[112&113].

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[105] Malone, Thomas, Joanne Yates & Robert Benjamin (1987): "Electronic Markets and Electronic Hierarchies", in Communications of the ACM, Vol. 30, pp. 484-497.
[106] Berryman, Kenneth et al. (1998): "Electronic Commerce: Three emerging strategies", in The McKinsey Quarterly, No. 1, pp. 152-159.
[107] Johnston, Russell & Paul Lawrence (1988): "Beyond Vertical Integration – the rise of the Value-Adding Partnership", in Harvard Business Review, Vol. 68, pp. 94-101.
[108] Bakos, Yannis & Erik Brynjolfsson (1993): "Why Information Technology Hasn't Increased the Optimal Number of Suppliers", in Proceeding of the 26th Annual Hawaii International Conference on System Science, pp. 799-808.
[109] Bolisani, Ettore et al. (1994): "Sharing in telematic network organisations: opportunities and entry barriers", in Gerard Progorel (ed.): "Global Telecommunication Strategies and Technological Change", North-Holland, Amsterdam, pp. 31-46.
[110] Forza, Cipriano & Andrea Vinelli (1996): "An analytical scheme for the change of the apparel design process towards quick response", in International Journal of Clothing Science and Technology, Vol. 8, pp. 28-43.
[111] Fornengo, Graziella (1988): "Interorganisational Networks and Market Structures", in Cristiano Antonelli (ed.): "The New Information Technology and Industrial Change", Kluwer Academic Press, Boston, pp. 115-132.
[112] Krause, Daniel & Lisa Ellram (1997): "Critical elements of supplier development", in European Journal of Purchasing and Supply Management, Vol. 3, pp. 21-31.
[113] Nielson, Charles (1998): "An empirical examination of the role of "closeness" in industrial buyer-seller relationships", in European Journal of Marketing, Vol. 32, pp. 441-463.

Some intermediate propositions have also been formulated e.g. as "move to the middle" [114] or as "mixed mode operations"[115]. Some of the attributes of the intermediate positions are market-like competition amongst a small group of pre-qualified suppliers. The pre-qualified businesses for the production networks offer required levels of production qualities, provide acceptable flexibility and timing levels, and apply ICTs in support for smooth value chain integration. Another aspect of the in-between proposition is that market-like structures may prevail in some sections of the value chain whereas integration is dominating other sections.

These contributions touch upon essential properties from applied ICTs on industrial organisation, but largely refrain from dealing with matchmaking institutions and procedures, and the development of new services and business opportunities. An evident trend from increased applications of ICTs is the separation of information from production-processes and an introduction of new services[116]. Specialised information services have developed that offer various facilities as financial services, market and trend analyses, technology information, and computer capacity in production and in sales. A special branch is the matchmaking institutions such as electronic marketplaces, information brokers etc. New matchmaking services provide new information on suppliers and buyers, and may pose as authentity-provides that guarantees minimum levels of skills and trustworthiness.

Summary

Analyses of selected economic theories indicate preoccupation with information-processing and one-way distribution: little attention is given to interactions and communications. To surpass the theoretical shortcomings this section has offered a communication model based on three layers. At the micro level information, interaction and communications are requisite for knowledge-formations: know-why, know-what, know-who and know-how. ICTs and DMM-technologies are supportive in these processes notably the shared multimedia files in product developments, and the videoconferencing tools in personalised communications for sharing worldviews and monitoring.

At the messo level firms interact through three contractual stages: Pre-contractual stages encompass search procedures and communication of worldviews, Contractual stages include product specification

[114] Clemons, Eric & Sashidhar Reddi (1993): "Some Propositions Regarding the Role of Information Technology in the Organisation of Economic Activity", in Proceeding of the 26th Annual Hawaii International Conference on System Science, pp. 809-818.

[115] Holland, Christopher & Geoff Lockett (1994): "Strategic Choice and Inter-Organisational Information Systems", IEEE Proceedings of the 27th Hawaii International Conference on System Sciences, pp. 405-413.

[116] "The Tradability of Banking Services: Impact and Implications" (1994), Current Studies Series, No. 27, United Nations, Geneva, "Information Technology, Services and Tradability", pp. 1-12.

and reward systems, and Post-contractual stages deal with delivery, payments and feedback. Applications of ICTs and DMM-technologies in this contractual stage impact the value chain structuring, which denotes the most aggregate level of the model. Value chains encompass the structures of material and information-belabouring, which due to market segmentations and customisations are increasingly based on extensive information sharing and communications. Businesses get more integrated just as customers get more involved in production developments, which compel businesses to share data and communicate on possibilities and future requirements. A crucial aspect of value chain structuring hence becomes the willingness and abilities to share information and engage in interactive relations.

2.4. Methodological Considerations

This section outlines the theoretical considerations made in this thesis in order to answer the posed research-questions. Though the above research-questions relate to different levels of abstraction and analysis they all relate to economic theory. Within economic theory there seem to be little consensus on the methodological premises except from a general application of hypothetical-deductive structures. Availability of data and the nature of statements in their research-fields determine if theoretical contributions should be based on either predictions or explanations. Theoretical contributions that seek to predict events are especially vulnerable to falsification-processes, just as explanatory contributions have to be justified and are especially vulnerable to logical inconsistencies that challenge the claims of realism. Theoretical contributions and statements are thus vulnerable to falsificationist tests and logical analysis at divergent extents. The qualitative approach to the research applied in this thesis has led to a focus on logical construction of statements and claims of realism as presented below[117].

Social theories are, in contract to theoretical contributions within most parts of natural sciences, complicated by absence of laboratory experiments and test-procedures that can disclaim or prove a certain hypothesis. The benefits from the laboratory research environments are an ability to reconstruct, confirm findings and identify significant causes through processes of elimination. Researches on human beings in their social context instead have to rely on observations of human behaviours under real-life circumstances that are impossible to defined and reconstructed. Within economic sciences it is not unusual to argue for some hypothesis given a specified set of

[117] Findings and arguments in this section have been heavily inspired by the works by Christian Knudsen (1991): "Økonomisk metodologi" (Economic Methodology), DJØF-Forlag, Copenhagen and Uskali Mäki et al. (eds.) (1993): "Rationality, Institutions and Economic Methodology", Routledge, London.

circumstances and then assume every thing else is unchanged or “equal”: Ceteris Paribus. If attempts to reconstruct the experiment in a similar setting yield deviating results, tautological claims are maid that every thing else apparently was not equal – otherwise the results would have been affirmative. The subsequent inability to reconstruct and confirm findings makes theoretical contributions somewhat less clear or evident, at least they seem less obvious to confirm and validate. Analysis of human behaviour is further complicated by possible discrepancies between human intentions and subsequent performances. Due to mistakes, chance events etc. it gets impossible to make tight correlation between intentions and events, which questions the ability to analyse levels of information and human cognitive processes in relation to their action.

Theoretical methodology within economics has for long been based on the hypothetical-deductive approach, which is applied in this work too. Within this methodological framework one should begin by collecting a set of data or facts from which it is possible to construct a set of laws through inductive processes. Construction of these hypothetical laws together with a set of circumstantial, specific conditions for the research enable deduction of some explanations or predictions. Proposed explanations and predictions then become subjects of falsification- or justification-processes. Stringent empiricists would argue that all theoretical statements are based on empirical findings and should be subject to falsification-processes, however apriorism advocates for a more methodological relaxed approach. In their view there exist some prior knowledge or information that we can take for granted and thus do not have to justify.

Within the hypothetical-deductive logical approach it is possible both to provide analytical predictions and to construct theoretical explanations. Symmetry of the logical construction allows predictions to be made from known theoretical laws and known circumstances; these predictions are then subject to falsification-processes. On the other hand, explanations of observed events can be made based on unknown theoretical laws and unknown circumstances, validation-processes are tightly related to logical construction of arguments. Whereas predictions and subsequent testability are important to large parts of economic theory, explanations, logic of arguments and realism are essential to other.

Economic research and theorising engulf a wide span of research focuses and subsequently a variety of argumentation and justification approaches. Depending on the focus of the research there exist different traditions for argumentation, validation and acceptability of theoretical findings. Lakatos proposes an instructive division of a given research programme into a theoretical core and a set of

circumstantial conditions[118]. Surrounding this analytical hard core there is a belt of protective and highly specific statements through which the researcher can specify the relevant conditions for the research. If the predicted events cannot be confirmed by collected data, then the theoretical construction gets falsified, which primarily imply that the circumstances were not unaltered and have to be redefined. The core remains intact within a given research paradigm. However, as successful falsifications mount the core will eventually give way for new theoretical constructions, new core statements and new research paradigms.

Within a given research tradition there exists a heuristic that stipulates which elements can be questioned and which methods to apply in justification-processes. Theories that yield results based on predictability would be very sensitive to successful falsifications. Theories of high realism, will on the other hand, will be less vulnerable due to their core capability of describing real processes – not predicting events. Research programmes hold different traditions regarding their justification-processes, which impact their vulnerability to falsification. Economic theories have been justified through application of a theoretical construct in a case study. The theoretical viability of the construction has then been justified either through claims of realism or through high predictability. Justification-processes for these two approaches are somewhat conflicting: Theories claiming realism often take an internalistic approach to human behaviour: encompassing individuality and diversity in actions. Though it is very compelling with an internalistic approach it is virtually impossible to falsify unless one unrealistically assumes that all observed actions are consequences of human intentions. The conditions for human choices and factor that impact personal strategies yield complex research situations that reduce research predictability and falsification-processes. Theories that claim to provide high predictability are often based on simplistic assumptions, which easily becomes in conflict with realistic circumstances.

When research traditions do not deal with the same questions, nor can be subject to the same falsification- or justification-processes, then it seems somewhat arbitrary which research programme accept and apply. Different research programmes may deal with the same or similar questions but at different levels of analytical abstraction. Laudau[119] argues that viability of academic paradigms depends on their lines of argumentation, internal logic structure, and applicability and realism to a given research question. Theoretical approaches hence depend on their internal language and their ability to deal with specific terms and research questions. Somewhat in contrast to these ideas,

[118] Op. cit: Knudsen (1991).
[119] Op. cit. Knudsen (1991).

arguments exist that emphasise the powers of an established research paradigm to define relevance of academic questions and methods: a research paradigm holds abilities to define relevance of terms and legitimately to disregard unwanted terms. Theories become immune[120,121&122].

Various theoretical constructions have offered analyses of information-processes, ICTs and their impact on economic behaviours. Some of the theories that pay special attentions to the role of information are transaction cost analysis, evolutionary economics and the new economy. In combination with industrial analysis, these theories provide some insight into the application of ICTs and the structuring of industry, however, individually they hold different approaches. These theories suggest application of some non-market institutions that impact economic agents through time. These contributions differ from their common background of neoclassical economic theory that only deals with one institution: markets, and that assumes information to encompass market conditions alone e.g. production costs. The core statements and research heuristics of the neoclassical and new institutional economic theories are extracted below in order to identify methodological differences and applicability in analysing information in industrial organisations.

Predictability Nexus

Neoclassical economic theory in its shape by Marshall[123] based on fully informed, rational agents and businesses that optimise their utility or profit, is a fine representative for the predictability nexus and testable methodology. This economic theory is very abstract and often provides testable statements for falsifications and justifications. Economic interaction is mediated through markets that immediately merge supply and demand. Only the firms that constantly maximise profits i.e. minimise costs will generate enough profits and survive the competition. The neoclassical approach has been criticised for many reasons relating both to the assumed individual motivation and properties of full information, as well as the market mechanism. Individual attributes of perfect knowledge and unbounded rationality are simplistic and unrealistic e.g. as it treats individuals as fully informed and businesses as homogenous black boxes converting inputs through universal production functions. Interactions amongst economic agents are either within employment relations where labour is treated quantitatively as any other input to production, or in arm-length market interactions. Markets are thought based on

[120] Kuhn, Thomas (1973): ”Videnskabens revolutioner” (The Structure of Scientific Revolutions”, Fremad, Copenhagen.
[121] Jürgen Habermas’ communicative rationality e.g. outlined by Heine Andersen (1988): “Kommunikativ rationalitet, velfærd og retfærdighed” (Communicative rationality, wealth and justice), pp. 146-176 in his “Rationalitet, velfærd og retfærdinghed” (Rationality, wealth and justice), Arnold Busck, Copenhagen.
[122] Michael Foucault’s knowledge and power outlined in Paul Rainbow (ed.) (1991): “The Foucault Reader”, Penguin, London.
[123] Outlined e.g. in Mark Blaug (1992): “Economic Theory in Retrospect”, Cambridge University Press.

singular transactions mediating the only relevant information i.e. prices as production cost and as value to the consumers.

Despite evidences against the theoretical core of rational optimising agents neoclassical theory has shown to be particularly resistant towards attempts of falsifications. Successful falsifications have instead been related to the situational constraints related to information-access: modifications have been offered in the model that touches upon the fully informed agents. Situational constraints have increasingly dealt with situations of imperfect information and technological changes. Information is however not given any independent status:

> "Information, rather, defines, permeates, and transforms other inputs and indeed entire production processes. Technically, information changes the production function, and consequently the cost curve." (Babe, 1995[124]).

Technology is treated as an input factor to the production function and full information ensures that all businesses are knowledgeable about optimal production functions. Technological developments lead to altered production functions, to shifts in capital-labour relations and cost structures. This approach to technological changes also applies to the emerging ICTs. ICTs are basically perceived as production capital and information as an entirely quantitative entity. This perspective has been somewhat contested by others, who suggest that information and ICTs offer entirely new economic conditions and changes of the techno-economic paradigm[125]. By and large, ICTs provide the businesses with new production technologies that shift the production functions and cost relations, labour get substituted by capital not only in the leading telecom industries but it diffuse and permeate all other sectors.

Within neoclassical theory there has been some modifications to the role of information in relation to assumptions on individual behaviour. Modifications have dealt with limits to information, costs of information and information-asymmetry[126]. Limited information and in-complete processing-abilities flaw rationality of decision-takers, but basically the decision-takers are still in pursuit of maximising processes. Simon proposes that individuals are cable of optimising results even though they do not hold full information and thus become bounded in their rationality[127&128]. Agents instead pose some

[124] Op cit: Babe (1995), p. 15.
[125] Freeman, Christopher (1988): "Economic Issues", in IEE Colloquium on 'Information Technology – Engineering the Future', Digest No. 23, pp. 1-3, p. 1.
[126] Lamberton, D (1992): "Information Economics: Introductory Remarks", in Cristiano Antonelli (ed.): "The Economics of Information Networks", Elsevier Science Publishers, The Netherlands, pp. 29-34.
[127] Knudsen, Christian (1993): "Equlibrium, perfect rationality and the problem of self-reference in economics", in Uskali Mäki et al. (eds.): "Rationality, Institutions and Economic Methodology", Routledge, London, pp. 133-170.
[128] Op cit: Simon (1995).

criteria for economic success and apply the first rule that satisfies these criteria, which as a consequence makes decision-takers act as-if they optimised (pursuit profit maximisation). Those decision-takers and businesses that do not follow the optimal rules will not survive market competition and hence wither away.

Bounded rationality not only impacts businesses' behaviours but also the consumers'. Agents in the neoclassical world are thought rational given some economic constraints, thought informed and able to value all possible sets of commodities, and thought in pursuit of self-interests i.e. are independent in their choice making. Bounded rationality touches upon all these attributes: notably the assumed self-interests[129] and independence from others have been questioned[130].

Explanatory Nexus

In response to the insufficiencies of the neoclassical economic paradigm in dealing with more realistic terms and conditions, modifications have been introduced to the core assumptions of fully informed individuals and pure market transactions. Modifications contest the highly abstract theoretical level and instead yield more realistic descriptions and claims. Methodological justifications of this approach reside with well-argued statements, abilities to handle relevant terms and questions, and with logical consistency. Verification-processes emphases realism instead of predictions.

Probably the first modifications to the highly abstract economic theory was introduced with the concept of "workable competition" has been introduced, which encompassed non-perfect competition: monopoly, advertising, product-differentiation and information processing through dynamic actions[131&132]. But "as workable competition never presented a consistent theoretical alternative to the Marshallian approach, its failure was inevitable."[133]. More consistent alternatives were provided with introduction of institutions and evolutions in economics.

[129] Rabin, Mathew (1998): "Psychology and Economics", in Journal of Economic Literature, Vol. 36, pp. 11-46.
[130] Granovetter, Mark (1985): "Economic Action and Social Structure: The Problem of Embeddedness", in American Journal of Sociology, Vol. 91, 481-510.
[131] Hayek, Frederich (1986): "The use of knowledge in society", in Louis Putterman (ed.): "The economic nature of the firm", Cambridge University Press, pp. 66-71.
[132] Op cit: Babe (1995).
[133] Auerbach, Paul (1989): "Competition: The Economics of Industrial Change", Basil Blackwell, London, Introduction pp. 7-30, page 21.

Initially perception of institutions in economic theory related to the role of individual habits e.g. in Veblen's conspicuous consumption and Commons' collective control[134]. New institutional economics differ from its predecessors through emphasising legal, financial, social and other institutional arrangements, how they affect individual choices, and how individuals affect them[135&136]. General characteristics of new institutional economics are that they allow for a much broader behavioural foundation, they focus on economic processes as opposed to static equilibrium analysis, and they include non-market institutions.

Behavioural Foundation

Within the new institutional and evolutionary economics actions are assumed influenced by information processing abilities and personal motivations. Individual abilities to capture all relevant information and consequences are restricted by limited capacities of the human mind, which leaves the rationality of the individual somewhat restricted i.e. bounded rationality. The real world is too complex to comprehend in full and events are somewhat influenced by chance, which make predictability and full information unrealisable features, and suggest that agents incorporate rule-following routines[137]. Instead of attempts to optimise behaviours in a world where consequences are unforeseeable, the individual will incorporate some forms of rule following in decision-making. Individuals are fundamentally perceived heterogeneous, which account for differences in skills and actions.

Varying motivations and different abilities to comprehend events impact rule-following attributes. Just as individuals differ in processing abilities they differ in motivation. Assumed differences in motivation, processing ability and access to information make accounts for the multitude of individual behaviours as well as of business strategies[138]. In contrast to the neoclassical paradigm this approach suggests that individuals differ in motivations and information-abilities, and economic decision-making depend on both information-access and past events.

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[134] Mäki, Uskali (1993): "Economics with Institutions", introduction to Uskali Mäki et al. (eds.): "Rationality, Institutions and Economic Methodology", Routledge, London, pp. 3-42.
[135] Op cit: Auerbach (1989).
[136] Langlois, Richard & László Csontos (1993): "Optimization, rule-following, and the methodology of situational analysis", in Mäki, Uskali et al. (eds.): "Rationality, Institutions and Economic Methodology", Routledge, London, pp. 113-132.
[137] Hodgson, Geoffrey (1998): "The Approach of Institutional Economics", in Journal of Economic Literature, Vol. 36, pp. 166-192.
[138] Nelson, Richard (1997): "Why Do Firms Differ, And How Does It Matter?", Nicolai Foss (ed.): "Resources, Firms, And Strategies", Oxford University Press, pp. 256-267.

> "If one thinks within the frame of evolutionary theory, it is nonsense to presume that a firm can calculate an actual 'best' strategy. A basic premise of evolutionary theory is that the world is too complicated for a firm to comprehend, in the sense that a firm understands its world in neoclassical theory... Thus, diversity of firms is just what one would expect under evolutionary theory. It is virtually inevitable that firms will chose somewhat different strategies. These, in turn, will lead firms to develop different structures and different core capabilities, including their R&D capabilities. Inevitably firms will pursue somewhat different paths." (Nelson, 1997[139]).

Economic Processes

An essential feature of new institutional and evolutionary economics is its rejection of static analysis and focus on economic processes. Markets and competition are not perceived as static attributes that lead to optimal allocations of resources. Instead, competition is based on the changing conditions and differentiated businesses that continuously innovates and adapts. Businesses hold differentiated routines, strategies and acquire different information and experiences leading to a large variety of business activities.

Businesses are not only components of change; importantly they encompass structures of continuity. They are given by their resources and knowledge-processes, which only change gradually. Indeed, historical events play important role in the present configuration of businesses, their developments core competencies and applications of technology, which becomes subject of path-dependent processes[140&141]. Development of core competencies and application of new technologies equally depends on interaction with market mechanisms and feedback-processes.

Non-Market Institutions

Business interaction is not only perceived as arms-length market exchanges: other forms of institutional arrangements exist that impact the business environment. Non-market arrangements such as financial, legal, social and information structures may equally impact economic activity. Financial institutions and the acquisition of operational capital are important to the risk taking of businesses and co-operative arrangements. Regulatory constraints impact areas of trade and market structures. Social relations are important in knowledge sharing, networking and co-operations. And information-processes are essential in business evaluation, interactivity and organisational arrangements.

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[139] Op cit. Nelson (1997), p. 265.
[140] Dosi, Giovanni et al. (1992): "Theory and History of Technology and Business Firms: The Microeconomics of Industrial Development", in Dosi, Giovanni et al. (eds.): "Technology and Enterprise in a Historical perspective", Clarendon Press, Oxford, pp. 1-26.
[141] Arthur, Brian (1990): "Positive feed-backs in the economy", in Scientific American, pp. 80-85.

Methodologically the new institutional economics provide much more realistic accounts of economic actions, but regretfully at the expense of simplicity and testability. Some of the methodological problems relate to the level of analysis where individuals compose the social groups, but also get influenced by others. The new institutionalists claim realism partly on the basis of more realistic individual motivations, heterogeneity of actors and erroneous processes, but as intentions cannot be directly translated into action due to errors and chance the claims are impossible to falsify.

Despite the above-mentioned common characteristics of the institutionalist and evolutionary approaches, there also exist evident differences[142&143]. Theoretical schools within new institutional economics that are of special interest here are transaction cost, evolutionary, industrial district and new economics. These theoretical schools are thought to be well suited to describe the organisational arrangement of the textile and clothing industry, or the application of ICTs, and hence relevant in a dual analysis of these phenomena. The contributions will be analysed in detail in chapter 6 on theoretical approaches, but briefly described below.

Briefly put, transaction cost economics analyses economic activity in a world of optimising agents but with costs of acquiring information. Transaction costs denotes the costs of searching and contracting which engulf all economic activities, consequently this analytical approach shifts the focal point of analysis from the decision-maker to the transactions[144]. The analysis proposes that transaction costs exist both within firms and at markets, and that economic organisation is governed by the minimising of production and transaction costs. In contracting the entrepreneur has to account for the risks from dealing with other individuals that are basically opportunistic, bounded rational and with assets that are specific to context[145]. Dealing in such environments, agents have to make some discounts for potential risks from mal-performances of others. It is argued that opportunistic behaviours are less pronounced within hierarchies, which make this a somewhat preferable organisational structure. However, the analysis is problematic as decision-takers are analytically granted perfect knowledge in order to make correct estimations of risks, which they can discount for in their contracting costs. But, existence of risks is logically incongruous with assumptions of perfect knowledge[146].

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[142] See op cit. Knudsen (1991).
[143] Foss, Nicolai (1993): "Theories of the Firm: contractual and competitive perspectives", in Journal of Evolutionary Economics, Vol. 3, pp. 127-144.
[144] Op cit: Coase (1937).
[145] Williamson, Oliver (1986): "What is Transaction Cost Economics?", in his "Economic Organisation. Firms, markets and Policy Control", New York University Press, pp. 174-191.
[146] Foss, Nicolai (ed.) (1997): "Resources, Firms and Strategies", Oxford University Press, introduction, pp. 3-18.

Evolutionary economics base their argumentation on natural sciences by accepting Darwin's notations of mutations and natural selection mechanisms[147&148]. An important difference compared to the natural science relates to the inclusion of individual influence on mutations i.e. purposefulness in mutations as argued by Larmarck in the socio-biological sphere[149&150]. Agents are believed to be bounded in their rationality and to apply routines in decision-taking behaviour. Organisational mutation relates to businesses' somewhat static organisational structures governed by routines and their abilities to innovate. In contrast to biology where genes are reproduced and mutate through breeding, organisational genes are reproduced continuously and mute as organisations incorporate new procedures. The consequences of organisational innovations cannot be fully analysed by the agent nor can the consequences be fully foreseen, which make these activities based on forms of trial and error processes. Markets perform selection mechanisms where conditions of survival-of-the-fittest prevail. The analytical charm of evolutionary theory rests with its focus on change in an unpredictable environment, however the realism claims are based on features that are impossible to falsify, just as there are problem with the sovereignty of the analytical unit.

Theories on industrial organisation include the value chain analysis and analysis of industrial clustering. Value chain analysis is relevant in this thesis at a general level where products and information get belaboured in a series of steps located with a range of specialised firms. However, value chains are not perceived as uniform one-directional linkages, instead communication-structures are bi-directional and work-organisation includes groups of firms. Theory on industrial clustering emphasises regional proximity and localised institutions like competition, trust and labour force[151]. Industrial district analysis describes that firms within districts are subject to combined forces of competition and co-operation[152]. Co-operation is partly ensured through a highly flexible labour force that shifts employment, establishes personal relations and distributes information. Analytical focus of this theory is placed on the social arrangement and networking attributes and no as much with individual decision-takers. The theoretical construction has to a wide extent been descriptive indicating political recommendations based on observed organisational structures. Less attention has been devoted to the micro-foundation for the organisational arrangement, but can be perceived as

[147] Op cit: Nelson & Winter (1982).
[148] Op cit: Dosi & Nelson (1994).
[149] Hodgson, Geoffrey (1994): "Evolution, Theories of Economics", in Hodgson, Geoffrey et al. (eds.) "The Elgar Companion to Institutional and Evolutionary Economics", Edward Elgar, Aldershot, pp. 218-24.
[150] Bonde, Niels et al (eds.) (1996): "Naturens historiefortællere", GAD, Copenhagen.
[151] Porter, Michael (1998): "Clusters and the New Economics of Competition", in Harvard Business Review, Vol. 76, pp. 77-91.
[152] Staber, Udo (1998): "Inter-firm co-operation and competition in industrial districts", in Organization Studies, Vol. 19, pp. 701-724.

agents restricted by incomplete information and with restricted rationality. Technology and organisational knowledge is transferred through the labour force, and personal relations govern opportunism and organisational structures[153&154]. Industrial analyses of district behaviours have emphasised the role of regional properties and social interaction, but this theoretical contribution has little to offer on individual business behaviours, nor on applied ICTs.

Where the industrial analysis falls short on analysing information-processes and applied ICTs, contributions on the New Economy succeed. Emphasis in the New Economy is on the technological development within ICTs that enable a separation of information and data from the physical production-processes and their transmitability, which leads to globalisation of information-processes and industrial restructuring[155]. This leads to organisational challenges, as information owners become more powerful: powers drift towards the information industry i.e. key producers, operating systems, applications and product definers[156]. Information-processes are thought structured by applied ICTs and their proprietary structures that confine economic advances to networks instead of to entire markets[157]. Generally, focus is on information-processes and the applied ICTs with a strong emphasis on the information and service industries. Application of positive feedback mechanisms and discussions of communication-standards in the New Economy indicates new organisations and new economic rules e.g. a gift economy: give products away for free, become the dominant provider and extra values later[158]. This approach discusses information and communication-languages, structures and technologies, but give little attention to the individual economic agents.

Summary

Highly abstract neoclassical theory and the subsequent institutional and evolutionary theories are somewhat incommensurable as they analyse economic activities at different levels of abstractions, and rely on different methodological verifications. Choice of methodological approach is not only a question about selecting a preferred mode of argumentation, but is also related to the nature of collected data and research-questions. The posed research-questions have been constructed through

[153] Op cit: Piore & Sabel (1984).
[154] Pyke, Frank & Werner Sengenberger (eds.) (1992): "Industrial Districts and Local Economic Regeneration", International Institute of Labour Studies, Geneva.
[155] Castells, Manuel (1998): "The Rise of the Network Society", Blackwell Publishers, Oxford.
[156] Cohen, Stephen et al. (2000): "Tools for thought: What is New and Important About the "E-conomy"", in BRIE working paper, Vol. 138, pp. 1-65.
[157] Mansell, Robin (1992): "Information, Organisation and Competitiveness – Network Strategies in the 1990s", in Cristiano Antonelli (ed.): "The Economics of Information Networks", Elsevier Science Publishers, The Netherlands, pp. 217-228.
[158] Kenney, Martin & James Curry (1999): "E-commerce: Implications for Firm Strategy and Industry Configuration", BRIE working paper, E-conomy project, paper 2, pp. 1-27.

iterative processes between data collection, posing hypotheses and testing/verifying. As the collected data for this doctoral thesis primarily has been based on qualitative statements, the research-approach has inspired detailed analyses, realism and methodological explanations. Hence, the methodological approach to this work emphasis the abilities to explain events and processes that are important, instead of residing with arguments of testability. The in-build claims of realism are based on arguments for individual limitations to information, economic adjustment-processes, and existence of non-market institutions, which are believed especially fruitful in dealing with technological advances that shifts the barriers for distributed interactions and communication-abilities.

2.5. Conclusions

In this chapter there has been offered an outline of research-questions and the analytical conditions on how to answer them. The first research-question deals with the roles of information and communication in economic theory at different analytical levels. The other two questions relate to the information and communication technologies, how they impact individual processes and the industrial organisations.

Economic theories offer different approaches and analytical levels. At the most abstract level of the theories considered in this thesis there is neoclassical theory, which assumes perfect information-processes and pure market-operations. Despite attributes of simplicity and analytical predictability, this theoretical construct is negated due to inappropriate levels of realism and inabilities to deal with communication-processes. Instead an explanatory methodology has been applied, which enables qualitative statements on communication technologies and prospects, and verifications through logical analyses.

A communication model has been presented, which draw on philosophical contributions on communication and knowledge, and from economic theory i.e. institutional and evolutionary theories. The model encompasses three levels: micro-level of knowledge-formation, messo-level of contracting, and macro-level of value chain structuring. Communications as an economic activity are important due to several reasons: generation of shared worldviews, product developments, learning, and for knowledge-formation. These attributes are reflected in the transaction-processes where businesses establish trusted relationships based on shared worldviews, together develop product specifications, and exchange knowledge about production-processes and other strategic information.

Chapter 3: ICT Developments and Applied DMM-Technology

3.1. Introduction

3.2. Multimedia Terms

- Texts
- Graphics
- Images
- Audio
- Video
- Summary

3.3. DMM-Technologies

- Networking Technologies
- Summary

3.4. DMM-Technologies for Textile and Clothing Industry

- Computer Aided Design
- Computer Aided Manufacture
- Electronic Sales
- Summary

3.5. Applications of DMM-Technologies

- Networking Technologies
- Digitised Production and Information Technologies
- Summary

3.6. Conclusions

3.1. Introduction

Digitised technologies in support for information and communication within and between businesses continuously improve the data-sharing processes. These continuous improvements enable creation, storage and retrieval of any type of data-files and media let it be text, graphic, audio, image, or video. Through improved processing-capacities, file-handling etc. computers have enhanced their abilities to manage and present multiple media at the same time. Technologies not only support the creation, editing, and sharing of such documents, they also provide facilities for an interactive use of these media as well as a distributed access. Distributed communication implies that ICTs are not only applicable inside enterprise-networks, but also across business boundaries e.g. through the Internet. Distributed Multimedia (DMM) technologies are not only the simultaneous application of multiple media for information and communication such as homepages, product presentations and virtual catalogues but are also related to aspects of distributed interactivity e.g. in shared workspaces and videoconferencing.

Developments in DMM-technologies constantly shift the possibilities for commercial and personal virtual interactions. This chapter offers an introduction to some of the DMM-technologies applicable for the industrial distributed and interactive processes in the textile and clothing industry. Emphasis is put on technologies that streamline the production-processes: enabling lean production i.e. small-batch production-lots fitted particular requirements, interactive product-development and support individualisation in production. Some of the key technologies are tools for computer-aided-design (CAD) and computer-aided-manufacture (CAM), which enable lean production-processes through shared files and automated processes. But also electronic search-processes and communication-tools that enable displays of skills, products, and media-rich communications are relevant. Media-rich communication as homepages, videoconferencing and shared workspaces are important to establish trustworthiness, shared worldviews, for product developments and economic decision-making.

This chapter deals with the technologies that make distributed interaction of multimedia files feasible. The development of DMM-technologies and increasing levels of application reveal that companies increasingly can interact through distributed networks, which offer larger and larger transmission-capacities. Increasing abilities to transmit DMM-files and of interactivity may impact on the business-processes and production-structures: information-access and -sharing is facilitated on a worldwide scale, which give new interaction-facilities and market-accesses, processes get automated and integrated, which enable internationalisation of value chains providing mass-customised products. In

analysing these features, attention is firstly brought to the composition of DMM-technologies and their requirements for data-transmissions and computing-abilities, which is followed by a discussion on the present networking facilities. Following this there is an outline of the relevant software for design and manufacturing processes for textile and clothing industry as well as an outline of technologies in support for economic decision-making e.g. on electronic sales and EDI-messaging (Electronic Data Interchange i.e. the electronic exchange of structured data). Finally, there is a status on the present applications of networking-technologies by Danish industry and on the use of digitised technologies by Danish textile and clothing industry.

3.2. Multimedia Terms

Generally speaking ICTs encompass all kinds of technologies that facilitate electronic communication through data processing, storage and exchange. These technologies encompass a wide range of functionalities and depend on compatible standards in their usage. Though the lack of compatibility is quite evident in most forms of electronic communication, the related problems are assumed slowly to diminish as ICTs mature, the Internet becomes more diffused and industrial standards develop.

DMM-technologies are a subset of the ICT framework[159&160]. Multimedia technology is not only the concurrent application of multiple media as text, graphics, images, audio and video but is also interactivity between different distributed nodes. Interactivity encompasses situations of simultaneous (or almost so) activity in a shared space like dialogues through videoconferencing, or shared workspaces like a virtual workbench. Distributed multimedia is when multiple media are applied in an interactive environment mediated through an electronic network, i.e. when the interactive processes are distributed amongst various nodes or interfaces.

Use of DMM-technologies implies that the applied hard- and software technologies support certain features required for both interactivity and the distributed nature. In order to support these features both computers and networks have to support simultaneous and synchronous presentation of audio and video/images just as presentations must be provided within acceptable delays. Whereas some electronic forms of communication easily can be stored and retrieved much later without any disturbance to the user e.g. texts or product catalogues; other forms of communication require immediate transmissions and synchronous presentation e.g. in videoconferencing and shared

[159] Agnew, Palmer & Anne Kellerman (1996): ”Distributed Multimedia – Technologies, Applications, and Opportunities in the Digital information Industry”, ACM Press, New York.
[160] Andleigh, Prabhat & Kiran Thakrar (1996): ”Multimedia Systems Design”, Prentice Hall, New Jersey.

workspaces. Distributed interaction requires that computers and servers interact fluently, just as networks have to transmit vast amounts of data in a limited span of time. Some of the technological constraints and challenges of present DMM-technologies are outlined below.

Texts

Plain texts are relatively easy to process, as each character is presentable through few bits. Through application of universal codes for letters, texts are easily coded and stored in digital forms. Digitised text-strings are also easily transmittable through most computer-networks, notably as required bandwidth and display requirements are low. Frequently the presentations of texts and digits are not sensitive to delays, but they are very sensitive to losses in transmissions: absence of single digits can be crucial in transmissions of finances.

Transmissions of texts and digits are often interactive in the sense that e-mails and EDI-messages offer the opportunities to respond. Downloading articles and homepages seems less interactive, however they can encompass interactivity through hyperlinks, where a selected part of the text through a hyperlink can refer to another text elements, image etc. Transmissions of texts and images through electronic networks as the Internet have to be encoded through structured markup languages in order to ensure readability by all forms of browsers. Markups are terms that describe how particular passages should be laid out. SGML (Standard Generalised Markup Language) is a metalanguage for describing all other markup languages, which ensures a unified code for text presentation.

> "By markup language we mean a set of markup conventions used together for encoding texts. A markup language must specify what markup is allowed, what markup is required, how markup is to be distinguished from text, and what the markup means. SGML provides the means for doing the first three" (A Gentle Introduction to SGML, 2001[161]).

SGML as a metalanguage defines the structures for other more specific markup languages such as HTML (HyperText Markup Language) and XML (eXtensible Markup Language). HTML is a very common publishing language that is well suited for creating hyperlinks and describing how browsers should arrange texts and images as well as the pressing of buttons. HTML is primarily concerned with appearances and not about content[162]: HTML-tags cannot describe what kind of information it is displaying[163].

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[161] "A Gentle Introduction to SGML", available at http://www-tei.uic.edu/orgs/tei/sgml, January, 2001, p.1.
[162] Bosak, Jon & Tim Bray (1999): "XML and the Second-Generation Web", available at www.sciam.com, December, 1999.
[163] "Pattern data exchange standards development revived" (2000), by Bobbin Publishing Group, available at www.just-style.com, November 2000.

Application of tags for appearances rather than content makes application of hyperlinks somewhat rigid and renders HTML insufficient for the emerging needs to transmit and communicate through less structured data. This shortcoming has been modified through construction of another markup language: XML that applies industry-defined tags for content such as size, price, unit etc. The benefits from content-related tags are evident e.g. as it makes searches and comparisons across different types of texts and documents much easier. Or in other words:

> "If HTML is about how to display the information, XML is about describing the data. If HTML is the picture of a building, XML is the blueprint of the building. After you feed a picture into a computer, the computer can do little with the image, except to display it. However, if the blueprint or engineering information is fed into the computer, the system can then generate different 3-D views of the building, perform stress analysis, alter the building layouts and change the design, etc." (Bobbin Publishing Group, 2000[164]).

The unifying strength of XML is that it deals with objects or contents that can be presented as desired by the reader irrespective of the actual language and software applications. Benefits are also substantial in searching information e.g. through application of industry-wide codes for topics and features: instead of manual navigation through documents for content or computerised navigation through highly structured and inflexible documents (as with EDI and EDIFACT[165]) navigation gets eased and potentially automated. XML enables searches for information based on industry-wide defined concepts like size, colour, designs and patterns i.e. through industrial agreement on codes for sleeves, buttons, zippers etc. XML-based searches provide much richer results. Applications of XML-based documents also open up for enhanced search mechanisms that scan documents for other attributes than given words or categories: searches may be based on virtual image-presentations.

Graphics

Probably the simplest presentations of figures are related to computerised graphics, which are related to computerised models, geometric figures, tables etc. Graphics encompass a wide set of figures that can contain many colours, points and lines, which require much bandwidth to transmit and capacity to visualise. To reduce these requirements, the graphics get coded through standard coding like DWF and DWG. The coded entities include points, vectors, fonts and colours. Through translating and combining coded information the computer is able to present the graphics i.e. through a viewer or decoder as Java[166]. For simplistic graphics like pie-diagrams and tables the required computer-

[164] Op cit. "Pattern data exchange standards development revived" (2000), p. 6
[165] EDIFACT is a global standard for EDI-messages in Administration, Commerce and Transport, www.edi.dk.
[166] www.javasoft.com (2001)

capacities are quite small: through data on centres, radius, points and colours, these graphics are easily generated.

With the increasing computing-capacities it has also become possible to generate much more complicated graphics e.g. computerised, graphic presentations of faces and bodies. In order to minimised the computing requirements, most of the computerised graphics are presented by simplistic figures i.e. presented by numerous large and small rectangular figures. Computing requirements thus get minimised, as it is much easier to calculate and draw straight lines than curves. Speedy and lossless calculations are especially needed for interactive environments where the viewer can change perspectives, sizes and colours[167]. As the technologies improve, the abilities to construct more detailed and photo-realistic images accelerate: "Texture mapping refers to the photo-realistic rendering of designs, colours, surfaces, textures and patterns onto photographs and other images"[168].

Applications of simplistic geometric figures have additional benefits when it comes to presentations of 3D-models. Graphic models increasingly get modelled and visualised in 3D-environments where the perspective can be moved around the object[169], and where the drawn figures can be positioned in different layers[170]. Shifting perspectives requires speedy and accurate presentation-abilities ensured through extensive computer-powers and simplistic coding and models. Improvements in processor-speeds and -capacities enable enhanced levels of presentation-details and interactivity of the modelled figures: models can be selected, positioned in individualised environments, manipulated for perspective, size, rotation etc.[171]

With increasing levels of details the computerisation seems less vulnerable to losses in transmissions and coding/decoding: with the calculations of countless points, it might be acceptable with a few misses. Delays are also acceptable for downloading and presentations of most figures, however for the interactive environments as shared workspaces, processes are very sensitive to delays.

Images

Presentations and transmissions of images like photographs and naturalistic artworks might be less complex than 2D- and 3D-models, but requirements are high due to the levels of detail and excessive

[167] www.cadviewer.com (2001)
[168] www.nedgraphics.com (2001)
[169] www.autodesk.com (2001)
[170] www.design-drawing.com/icad (2001)
[171] www.janet.de (2000)

number of points or pixels i.e. the coloured points used for screen-presentations. Images are quite detailed and do not enable any simplistic coding in contrast to the geometric figures and graphics, as they only contain little abundant information. A standard-sized image for full-screen display could e.g. be composed of 1600 pixels per row in 1200 rows, which compel the computer to calculate information for almost 2 million pixels. Image processing thus requires much processor-capacity for presenting all details.

Like most other visual media the images are composed of shades of red, green and blue (RGB-colours) at varying intensities (shades of grey). Depending on the set-up of the computer and screen, images may be presented with very high colour-realism i.e. "true colours" (32 bit a pixel). Computer-screens can display any of the colour-combinations in all of its pixels. Processing-requirements are not only extensive due to the many pixels and colours, the requirements for screen-displays become immense as the brightness of pixels rapidly decay on screens, and as screen displays flickers unless updated 60 to 72 times per second[172].

As processing and bandwidth requirements are so overwhelming in dealing with full-screen images, the mentioned requirements are often relaxed through different means e.g. less than true colours, or less than full screens. Another widely applied means is to compress data through compression-tools like JPEG[173]. JPEG image-compressions are applicable for still images where redundant information gets extracted coded and subsequently decoded for visualisation. JPEG-based coding and decoding is subject to some losses, which implies that the final image differs from the original. Degrees of lossiness can however be adjusted through trade-offs in file size and decoding speed against image-quality, the latter as fast but inaccurate approximations gat applied.

Lossy compressions are not necessarily problematic for the human eye, but may be problematic for computerised image-readings. Nevertheless, lossy compressions may be preferable due to degrees of compression:

> "There are lossless image compression algorithms, but JPEG achives much greater compression than possible with lossless methods. JPEG is designed to exploit the known limitations to human eye, notably the fact that small colour changes are perceived less accurately than small changes in brightness. Thus, JPEG is intended for compressing images that will be looked at by humans." (What is JPEG?", 2001[174]).

[172] Op cit: Agnew & Kellerman (1996).
[173] www.jpeg.org (2001)
[174] "What is JPEG?", available at www.faqs.org/faqs/jpeg-faq/part1/section-1.html April 2001.

Audio

Digitisation of sound is another essential element of ICTs. Conversions of analogue sound into digitised data-strings are accomplished via microphones that code sound into digital numbers: bits. Resolution of sound depends on the number of samples per second and the number of bits per sample. To achieve high quality sound it is required that samples are both frequent and based on many bits per sample.

Ordinary voice telephony is based on 8,000 samples per second and 8 bits per sample, which is equal to the 64 Kbps provided through the standard telephony network[175]. Better sound-qualities require higher capacities, e.g. 96 Kbps provided by Windows Media Player. Stereo audio at normal CD-quality requires 2 channels of 44,100 samples per second and at 16 bit per sample: Equal to 1,4 Mbps.

Audio is also compressible and numerous standards exist e.g. MP3 (MPEG audio levels 1, 2 & 3) and WMA (Windows Media Audio) there are numerous (free) audio players e.g. Winamp[176], RealPlayer and RealJukebox[177]. Compressions of audio are mostly lossy e.g. Silence Compressions where sounds under a certain threshold are treated as noise get filtered and ignored, likewise for audio-compression in the Pulse-code modulation. Probably the most widely applied audio-compression tool is the MP3, which under the MPEG-1 standard enable about 0,3 Mbps for audio. Rates of compression range from 3 to 24:

> "With compression rate 6:1 (16 bits stereo sampled at 48 KHz is reduced to 256 Kbps) and optimal listening conditions, expert listeners could not distinguish between coded and original audio clips." (Audio Compression, 2001[178]).

Whereas disruptions in the sound quality are easy to detect e.g. noise or temporary silences, it is often easy to make repetitions. Thus, sounds like images are not as sensitive to losses as texts and data-files are. One of the challenging elements of transmitting audio is the delays in interactive environments e.g. Internet-telephony and videoconferencing:

> "One-way delay of more than ½ second begins to get annoying in a real conversation; the two sides will start to speak at the same time, then stop, then start again, and so on. Carrying on an interactive conversation with one-way delay of more than ¾ of a second is practically impossible." (Videoconferencing Quality Tester, 2001[179]).

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[175] "Understanding Telecommunication" (2000), Telia & Ericsson, Sweden, extracts, pp. 1-25.
[176] www.winamp.com (2001)
[177] www.real.com (2001)
[178] "Audio Compression", available at www.cs.sfu.ca/undergrad/CourseMaterials April 2001
[179] Videoconferencing Quality Tester – Zydacron,inc, available at www.zydacron.com April 2001.

Video

Video is the sensation of moving images obtained through a continuous flow of still images and through flickering of the screen. Full motion pictures casted through TV will contain approximately 30 images per second and flicker about 60 times a second. Digital video mediated through computer screens is subject to similar requirements and updated at 60 to 72 times per second. With 1600 pixels per row and 1200 rows and e.g. 32 bits per pixel and 30 images per second, the computing requirements of digital video exceeds 1,8 Gbps. These requirements vastly surpass the present capacity of telephony networks.

Digital video is nevertheless an important element of present DMM-technologies. More workable versions of digital video relax these extensive requirements e.g. through reductions of image-sizes. However, much digital video is only displayed at about 25 percent of the total screen and with smaller resolution: video image of 320*240 pixels and 24-bit RGB-colours, which reduce requirements to 56 Mbps. Compressions of audio and video also get applied and can either be symmetric if the compression-processes are equally powerful to the decompression, or asymmetric if the compression-processes are more extensive than the decompression. Compressions can easily be asymmetric for high quality videos, but has to be symmetric for real-time interaction as videoconferencing.

One of the most widely applied Internet-based compression-standards for video and audio is the H.261 standard, which enable coding and decoding of digital transmissions over low bit-rate lines i.e. at 64 Kbps[180]. MPEG is developed for motion picture compression e.g. applied by RealPlayer[181], and differs from the JPEG processes by applying both inter- and intra-frame compression[182]. That is, compression subtracts redundant data and the inter-frame compression makes recording of the pixels that change from one image to the next, which will be the core information for decompressing. The advantages from this compression-tool are vast as decompressions can concentrate on those elements that have changed. There exist various versions of the MPEG tools. MPEG-1 has been developed for CD-quality video signals i.e. about 1,5 Mbps. The MPEG-2 standard has been developed for processing video at full resolutions for the broadcast industry, and has little relevance to Internet-based interactivity. Instead, the latest compression standard MPEG-4, is especially promising for enabling storage, transmissions and manipulations in multimedia environments:

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[180] Ghanbari, Mohammed 1999): "Video Coding, an introduction to standard codecs", The Institution of Electrical Engineering, London.
[181] www.real.com (2001)
[182] Cheesbrough, Elizabeth (2000): "The Ins And Outs Of MPEG", available at www.rcc.ryerson.ca, June, 2000.

> "The approach taken by the experts group in coding of video for multimedia applications relies on content-based visual data representation of scenes. In content-based coding, in contrast to the conventional video coding techniques, a scene is viewed as a composition of *video objects* with intrinsic properties such a shape, motion and texture. It is believed that such a content-based representation is a key to facilitating *interactivity* with objects for a variety of multimedia applications. In such applications, the user can access arbitrarily shaped objects in the scene and manipulate these objects." (Ghanbari, 1999[183]).

Presentations of videos mostly require a concurrent transmission of audio. Within the MPEG compression, the data packages contain only one elementary data type (data, video or audio), which calls for multiplexing in order to stream and synchronise presentations. Video and audio signals have to be synchronised in order to compliment each other, otherwise delays in one of the streams will be very disrupting and annoying. Synchronicity is not only important for video-streams, interactivity and minimum delays are also essential for videoconferencing. Interactivity necessitates that images and sounds get encoded and not stored on static files, but encoded, casted live, and decoded by the receiver. Low-quality videoconferencing is possible through the 64 Kbps. provided by the telephony networks, but that lead to small image-presentation and dissatisfactory data-flows[184]. Higher standards require higher bandwidth e.g. multiple telephone lines, and "fully acceptable" levels of live video-communication, they argue require transmission-capacities at 1,5 Mbps.

Besides the functionalities provided by each of the above-mentioned interactive conferencing-tools and shared workspaces, the interactive communications often require application of both forms. That is: distributed, shared workspaces often require that the actors can communicate personally i.e. they need an additional audio-line provided either by Internet-connectivity, alternatively by ordinary telephony[185]. Likewise, videoconferencing often requires some form of data-collaboration: the ability to transmit images, shared files etc., calls for additional computer-capacities and transmission-bandwidth.

Summary

DMM-technologies encompass combinations of text, graphic, image, audio and video. Another attribute is the interactivity amongst distributed nodes based on transmissions and simultaneous presentations of video, audio and data components. Digitised transmissions and interactivities are

[183] Op cit: Ghanbari, 1999, p. 191.
[184] Op cit: Andleigh & Thakrar (1996).
[185] Carl, Constantin presentation at ITIT, Information Technologies In Textile and Clothing, Como, Italy, on the shared workspaces by www.janet.de (2000).

subject to special requirements for processor-abilities and transmission bandwidths, and they are sensitive to losses and disruptions at different degrees. Internet-based telephony, which have not been discussed much above is probably the least sensitive to losses as it is easy to repeat what has been lost, likewise the strains on the computer-networks are minor.

Table 3.1: DMM-data, sensitivities and requirement levels

	Sensitivity to losses	**Sensitivity of delays**	**Processor and bandwidth requirements**
Texts/Data	High	Low	Low
Graphics	Medium*	Medium**	Medium
Images	Medium*	Low	Medium
Audio	Low	High	Low
Video	Medium	High	High

Note: *) sensitivity to losses is only low in the case of human reading, whereas computerised analyses will be very sensitive to losses. **) sensitivity is low for most transfers, but high in shared workspaces.

Compression-tools have continuously improved just as the capacities of computers and networks have risen. Increasingly complex files can get transmitted in networks and manipulated by distributed nodes. HyperText files are especially applicable for homepages and presentations of texts etc. Introductions of XML-based codes shifts focus towards contents and enhance the uniformity of presentations, which have vast commercial potential: searches in XML-based documents reveal new opportunities for matchmakings, as identifications may be on industry-defined product codes, colours codes etc. Even though it is technologically possible to screen images for special colour-combinations e.g. in porn-censorship, browsing is more likely to be based on texts and (colour) codes.

Advances are also evident in graphics where developing technologies support more and more complex image-presentations: more details, more presentation facilities and 3D-modellings. Internet-based tools increasingly support interactivity between distributed nodes with reducing requirements for the translating software. Object based coding, which further enable distributed manipulation of multimedia files, also assists interactivity. Shared workspaces increasingly emerge as an Internet-based, cheap functionality, applicable for small and medium sized enterprises.

Presentations of images, video and audio likewise get assisted. Compression-tools and computing-abilities assist evermore detailed and accurate presentations and visualisations, just as technological advances increasingly support interaction as videoconferencing. DMM-technologies provide medias for interactivity that have great commercial prospects: managers and specialists may communicate in a media-rich style where facial mimics and hand movements get presented. It becomes possible to monitor others' activities, share files and information on production, control etc. And the shared workspaces support online product-developments and alterations for personalised fitting.

3.3. DMM-Technologies

Developments in computer-processors, compression-algorithms and transmission-capacities have opened up for increased commercial usage of DMM-technologies e.g. in interactive product-developments and videoconferencing. Innovations in DMM-technologies have not only enhanced the individual computers' ability to handle increasing levels of data-complexity, and process audio and video synchronously, innovations also enhance the computer-abilities of integrated processes and interaction with other computers in electronic networks.

Increasing levels of computer hardware and software-standardisation enhance the compatibility of products and of different programmes to share files without dedicated translations. In order to obtain smooth interactivity amongst distributed nodes and different software-programmes it is required that file-formats be transformed from one software to the next without time-consuming or incomplete translations. Further, to enable the interactivity of programmes distributed in open-ended networks it is required that software-interactivity be enabled without expensive or proprietary programme-alterations. Standardisation of hard- and software within DMM-technologies for the textile and clothing industry has been enhanced with the advent of the Internet. Increasingly interoperability of programmes are provided by a number of different vendors, however interoperability across software vendors is as yet only limited.

Equally important to ensure interactivity in distributed networks is the ability of different nodes to connect and transmit data at required speed. Present capacities are either limited or quite expensive; transmissions through the telephone network only offer limited bandwidths, and true broadband solutions are still quite expensive. Rapid technological developments and heavy investments in the telecommunication infrastructures are altering this situation; transfer modes develop, modem

capacities get upgraded, local loops get improved just as the telecommunication backbone and general networking capacities, let it be wired, fixed-wireless or mobile are all upgrading rapidly.

Increasing requirements by private and commercial users to process DMM-files have put special strains on vendors to supply ample processing-powers in computers and subsequently enhanced storage-capacities. Developments of computer hard- and software have impacted the distributions of tasks between servers, networks and individual workstations, where co-operative and shared workspaces increasingly get supported. Individual workstations have consequently gained an altered functionality as gateways to shared networks and shared workspaces; developments have increasingly stressed the interactive milieu, presentation-facilities and compatibility of software. The changed distribution of tasks between main computers and distributed workstations includes increased processing-powers of the servers and networks, and smooth interactions with the workstations. Abilities to store, retrieve and manipulate multimedia-data are increasingly located with servers and networks. Local workstations instead apply software that enables access to the centrally stored files. Increasingly distributed workstation becomes an interface for showing files that are processed elsewhere, and a interface for interacting with other nodes. As multimedia-data to a large extent is based on graphics, images and video-presentations, the storage-requirements have multiplied manifold as compared to storage of plain text-elements. Through centralisation of storage and processing functionality it becomes easier to interact in distributed networks.

Concurrently with the improved computing-abilities the networking capacities also get upgraded. Two central transfer-modes exist for electronic networks i.e. circuit switching and packet switching[186]. The circuit mode is applicable for ordinary voice telephony as connections between two or more nodes get established and reserved. Through this circuit-switched transmission-mode connectivity can be established between any nodes, which then occupies the line irrespective of transmissions or not i.e. the line is taken no matter if the persons talk or not. Advantages are low rates of delays and data-losses: the former is important for distributed interactivity and the latter for transmissions of some loss-sensitive data-streams.

As this transfer mode only provides limited bandwidths and generally low utility of the established telecom networks, an alternative packet switching has been introduced, which enable transmissions at larger bandwidths but also with higher delays and disruptions. Different packet-modes exist, which

[186] Op cit: “Understanding Telecommunication” (2000).

deal with different layers and provide different opportunities e.g. X.25 providing high utilising of bandwidth-capacities through line-sharing, but less than broadband capacity, or the asynchronous transfer mode (ATM) that offers very high rates (e.g. 100 Mbps) and flexible bandwidths. Packet-mode transmissions can be either connection oriented, like the circuit switching, or connectionless, which is based on packages finding whatever possible route to its destination. The connectionless packet-mode offers possibilities to utilise the network capacities, but may delay parts of the transmissions. One such structure is found in the Internet-based IP/TCP protocols, where file-transfers get time-stamped and opened in the right order. An advantage with of the ATM-technology is that connection-oriented transfers are enabled at the same time as flexible bandwidth enables large data-transmissions.

Networking Technologies

Distributions of large multimedia-files within distributed networks have enhanced the requirements for bandwidth for both internal and external electronic networks. Structures and capacities of electronic networks have undergone revolutionary changes within the past decades relating to both technological improvements in telecom-infrastructures and accesses, just as the unit-costs of telephony have decreased due to deregulation and competition. Some of the most relevant new communication-technologies that provide improved data-transmissions are outlined below.

Deregulation and technological innovations have meant that an increasing number of access-technologies have emerged, which allows for competition in the access to the larger telephony network. With the general upgrading in telecom-backbones and improved local accesses to competition is increasing evidently; the cable-television infrastructure has partly become viable for interactive data-transmissions, Fixed Wireless Access (FWA) enables high-capacity data-transmissions, and mobile telephony in the 3rd generation UMTS technologies are enabling broadband-accesses too. Other access-technologies also mature and show competitive abilities e.g. satellite communications, optical fibres to homes and the power network[187].

Public provisions of telephony services have traditionally been based on switches at 64 Kbps. These switching-capabilities have been fully satisfactory for the provision for conventional voice telephony and embodied in 56 Kbps. modems. But with enhanced requirements from increasing data-transmissions, these service-levels have become dissatisfactory. Means to avoid the shortcomings from

[187] Melody, William (2000): ”Trends in European Telecommunication”, report for Telestyrelsen, National Telecom Agency, Denmark, CTI, pp. 1-52.

this access-technology include upgrading local access-technologies. The backbone-structures in the telephony network have continuously been upgraded especially through the applications of fibre-optic cables, and local accesses and loops are also getting upgraded. Probably the easiest form of extending access is through multiple telephone-lines and ISDN-modems. The typical ISDN-solution (Integrated Services Digital Network) is based on dual telephone-line and provides access of 128 Kbps both ways. ADSL-connectivity (Asymmetric Digital Subscriber Line) is also based on the telephony networks, but provides uneven transmission and reception-abilities. Basically, the ADSL-technology provides an open flexible access to the communication-networks that delivers access when required, which is unlike the ordinary telephony connectivity that offers a fixed lined and continuous connectivity. ADSL often offers 128 Kbps upstream and for 512 downstream for the individual user, but could support transmissions up to 2 Mbps. Future development of the DSL connectivity allows broadband capacities both ways e.g. SDSL (Symmetrical DSL) and HDSL (High bit rate DSL) which works on dual lines. VDSL (Very high speed DSL) offers connectivity of 50 Mbps for customers within a few hundred meters from local central[188].

Some of the emerging networks for telecommunications have originally been constructed for other purposes e.g. cable television and power-lines, and hence do not contain the typical 2-way connectivity. Whereas the transmissions of data through power-lines are still in a developing stage, data-transmissions have already been enabled through the cable networks. In order to transform cable networks into two-way communication structures, other switches have to get incorporated. Introduction of feedback structures will however not alter the asymmetric transmission-capacities i.e. much higher capacities downstream than upstream. Transmission-needs for most multimedia-files are higher downstream than upstream i.e. requirements for accessing data e.g. video-on-demand, but interactive environments often require symmetric accesses. Compared to the ADSL-connectivity, the cable networks often provide much high bandwidths e.g. 30 to 40 Mbps, but at a shared basis i.e. the use of the cable network by one user restricts the resources for other users. Another difference relates to the expensive connectivity where the high establishment-costs restrict the viability of cable networks to urban areas. Cable-modems often confine the access by the single user to 1 Mbps downstream and some hundred Kbps. upstream.

In order to satisfy the increasing needs for transmitting large data-streams within and between businesses, some private networks and connections get applied. Dedicated satellite-links offer a

[188] www.computerworld.dk (2001).

broadband-connectivity without establishing connectivity through physical cables. The advantage is that satellite-connectivity is broadband and is sometimes cheaper than the physical cabling; however it remains an expensive solution. Local Area Networks (LANs) are provided through lines at about 100 Mbps., which suits data-needs by most businesses. The LANs provide businesses with a transmission-network through which the distributed workstations can get connected. Connectivity to other nodes outside the local area network can e.g. be obtained through extensions as leased lines offered by in the Wide Area Networks (WANs), or by public networks.

On the wireless side, access technologies have developed remarkable in past years. FWA, mobile GSM and satellites are some of the maturing transmission technologies, and a 3rd generation mobile telephony UTMS is a promising technology for the future. FWA-transmissions are based on a wireless connectivity between stationary nodes through the ATM-technology; through local transmitters and receivers the individual node can get connected to large communication networks. FWA enables high transmission-capacities and have become suitable as LAN-solutions. Due to receding quality of transmissions with increasing distances, the FWA technology is especially applicable for transmissions in a radius of no more than 10 km. e.g. local LAN-based transmissions for a business[189].

Summary

DMM-technologies continuously develop and provide enhanced functionalities applicable for commercial purposes. In order to extract the full potentials from interactivity and multimedia applications, businesses increasingly require large bandwidth for data-transmissions, continuous accesses to networks and interoperability of software. Software programmes increasingly support interconnectivity through applying standard file-compressions and Internet-enabled user-interfaces. And the networking technologies increasingly support both continuous accesses in support for interactivity and large bandwidths for large multimedia-transmissions.

Transmission-technologies for texts and data are relatively fine: requirements are low except on data-losses where transmissions are very sensitive, modified through circuit-switched, low bandwidth connections. Transmissions of other multimedia data-types are less sensitive to losses, but they have higher requirements for bandwidth, immediacy and interactivity. Generally, there are trade-offs between data-capacity and delays in transmissions: transmissions of large files have disabled interactivity. But, new switching-modes and improved transmission-networks, which increasingly

[189] www.pcworld.dk, (2001).

enable simultaneous interactivity and applications of many medias, also enable increasing bandwidth and interactivity of DMM-technologies. In addition, the introductions of packet switched transmission-modes enable new possibilities to remain online continuously: lines are always accessible, providing flexible bandwidths.

3.4. Applied DMM-Technology

Just as the networking technologies have developed so have the software that utilise these transmission-services. A wide range of applications and terminals has developed that supports file-transfers across software-packages and programmes. Software-programmes that have been introduced decades ago based on proprietary standards, have increasingly become enriched by Internet-based interfaces, which enable improved interactivity with other programmes. Digitised processes can progressively become integrated with other processes in distributed structures, irrespective of software vendor and software-packages. Some of the applications that are of special importance to the business-to-business interactivity in the textile and clothing industry are described below. A status on the diffusion of these technologies in the Danish textile and clothing industry is given later in this chapter.

Computer Aided Design

Design processes have become highly specialised tasks performed by specialists either employed directly by producing, manufacturing or retailing companies, or as independent service-providers e.g. freelancers or agencies. Digitalisation of design has been a major technological innovation that has enabled a separation of this function from the other production functions. CAD is hence a very important application that has developed with the increasing networking opportunities. Computers increasingly get applied in the designing processes and the digitalisation of designs has had a direct impact on the organisation of manufacturing processes. Computers in design are basically applied for commanding images based on various inputs, computed through complex programmes and displayed at distributed terminals. The programmes are often very complex as software-developers are faced with mounting demands for realistic image-presentations: presentations have to get evermore detailed, accurate and in 3D. Further strains on the computing and networking abilities are the mounting requirements for dynamic drapes i.e. moving models, and interactivity in displaying designs and models. To provide workable alternatives to production of physical prototypes, the CAD-programmes have to offer realistic displays of clothing worn by moving virtual models. Present computer abilities and networking technologies are strained to the edge in providing these functionalities.

Applied CAD-technologies suit two ends in construction of designs: fashion sketching and pattern-making. The sketching process of fashion making relates to manipulating different pieces of virtual materials into a preferred design, which get visualised on a screen. Through these processes the designer get liberated from physical trial-and-error procedures and tedious, time-consuming processes of physical prototyping on dummies or real models. Digitalisation of this process has important implications for time, costs and flexibility of designing: it becomes much easier to manipulate colours and patterns, and to visualise new ideas and combinations. As time-consumption is reduced so are the associated costs. The second issue of CAD-technology is creation of patterns for cutting and assembling of the fabric. Computerisation of the designing process enables quicker alterations of models and fast calculations of patterns for further processing. Calculation of patterns for cutting can be quite complex related to decisions on optimal pieces, darts and rims to sew, which often has to be recalculated with any major alteration to the model.

Figure 3.1: Garment creation

Source: Citer, (2000)[190].

A more thorough analysis of the designing processes suggests that CAD-technologies can be divided into 6 separate steps that are faced with different challenges to software-developers and computer-capabilities[191]. These steps are 1) obtaining body data, 2) garment creation, 3) modulation of fabrics, 4) pattern generation, 5) pattern visualisation and garment assembly, and 6) interface designs.

Accurate data from digitised body-measurements have already been accomplished. Through body scanning procedures it get possible to measure body-sizes accurately in a very short period of time: in less than 15 seconds[192]. The person is placed in a scanner, illuminated by vertically moving light and

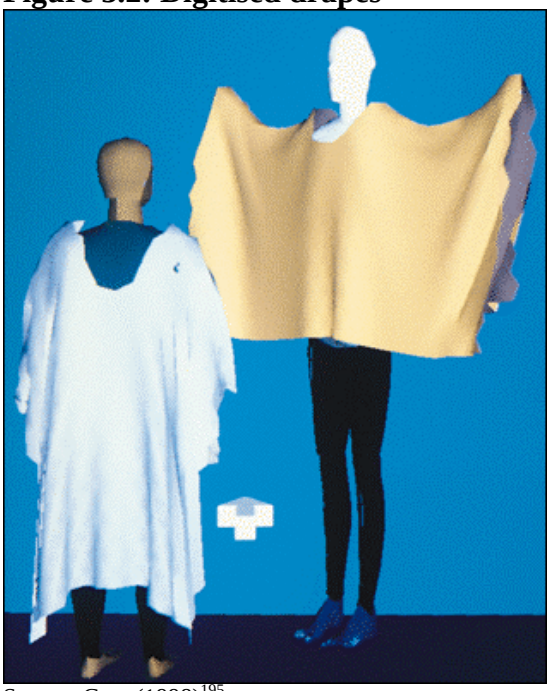
[190] Win Texture, a texture mapping application provided by Citer, Emilia Romagna Textile Information Centre, Carpi, Italy (2000), available at www.citer.it, April 2000.
[191] Hardaker, C & G Fozzard (1997): "Towards the virtual garment: three-dimensional computer environments for garment design", in International Journal of Clothing Science and Technology, Vol. 10, No. 2, pp. 114-127.
[192] www.lectra.com/en/solutions (2001).

monitored by a set of cameras that reads the shades. Stereoscopy is another means to obtain body-measures[193]. Accurate measures are obviously important to processes of individualisation of manufacture but also for mass-produced items. Fitness of standard-sized clothes is subject to changes as body-forms develops in conjunction with clothing, as materials hold different elasticity, and as fashion demand new degrees of body-fitness.

> "Now, in the late '90s, the actual woman is more likely to have a figure defined as 91—69—94 cm yet the '50s' "ideal" *(91—61—91 cm, my addition)* by and large still reigns in the industry. Underwear, too, plays its part in the changes, as body-hugging garments made of flexible materials have replaced the rigid bras and the corset of 50 years ago." (Gray, p. 1998[194]).

Garment can be created through different approaches in a virtual environment. A so-called "first principle" provides a tool-kit based on connecting panels around the mannequin. From the marked panels it gets possible to move and alter each panel at a time. Realistic visualisation through this modelling approach is obtained through curve-fitting algorithms at the edges of the wanted areas. Later approaches have integrated 3D-functionality based on stylised facts about the fabric e.g. on how they bend and their elasticity.

Figure 3.2: Digitised drapes



Source: Gary (1998)[195].

[193] Kang, Tae & Sung Kim (1999): "Optimised garment pattern generation based on three-dimensional anthropometric measurement", in International Journal of Clothing Science and Technology, Vol. 12. pp. 240-254.
[194] Gray, Stephen (1998): "Virtual Fashion in Virtual Reality", available at www.institute.ieee.org/select/0298/vr.html, April 2000, p. 4.
[195] Op cit: Gary (1998), figure 7, http://www.institute.ieee.org/select/0298/vrf7.html.

Modulation of fabric for virtual display is very complex and the higher the need for realism the larger the sensitivity and need to make precise calculations of right shape of drape, colours, light etc. A complicating issue is that, just as they lack uniform standards for sizes, there is an absence of any industry-wide standards for describing fabrics. Two different approaches have been applied in order to generate realistic visualisations. One approach is based on geometric models that calculate the right shapes of fabrics, but this requires very complex programmes and extended processing powers. Another approach is based on stylised facts generated from physical models, calculations are performed on mechanic and elasticity theories. This approach requires less computer capacity but a prior knowledge about materials and their performance.

One of the major problems of making a model for virtual realty, besides making accurate visualisations of the fabric and drape, is to generate realistic movement to the virtual mannequin for dynamic drape. This puts extra strain on the computing and networking requirements as continuous calculations and/or transmissions have to be provided. Besides modelling right movements of the body, the programmes have to account for fabric-body and fabric-fabric collisions and interactions. "However, the computational time required for the simulations is prohibitive and, at present, cannot be achieved in real time." (Hardaker et al., p. 120[196]). Less demanding modelling approaches has been applied based on mechanical data on a fixed range of known fabrics. Simulations can be obtained through application of less demanding and accurate fabric-body collision routines, which restricts the provided realism of virtual models. Latest technological improvements have enabled provisions of realistic photographic-like presentations of constructed materials and designs e.g. through software from MIRALab, e:dress and NedGraphics[197].

Generating cutting patterns for production is another major application-area for CAD-technologies. In order to construct accurate cutting patterns from chosen designs, the CAD-programme need some precise fitness instructions and dressing algorithms. The pattern making processes require garment assembly routines to join different pieces of cloth into the design product, which impact on the calculation of extra rims for assembly. Pattern making processes for cutting are complicated by the need to make 2D-patterns from 3D-generated and visualised designs. Hence, the model is designed in a 3D-environment and has to be flattened into 2D-images, which is accomplished through flattening algorithms that at the present state of the art can only offer approximate cutting patterns. Some of the hurdles associated with full automation of the pattern generating steps are associated with identifying

[196] Op cit. Hardaker & Fozzard (1997).
[197] www.just-style.com (2001).

the best cutting and fabric alignments and scalability of models. CAD-programmes offer some automated cutting patterns but they need to be supervised by skilled manual labour in order to ensure the correct features[198].

As a final consideration on the CAD-technology there is the interface, which have undergone alterations too. The 3D-models are visualised on 2D-screens, and the applied tools and software increasingly support 3D working environments e.g. AutoCad's ability to isolate single objects, manipulate them and present them with realistic lighting etc[199]. Interface developments also enable smoother alterations of materials e.g. sketching of models directly on the screen through cordless pens and touch-sensitive screens. Sketching is done through keyboard operations and by applying cordless pens and tables for colours, materials and the like. These tools offer opportunities to visualise the model from any angle, perspective, size etc. It is legio that not only the designer is able to manipulate the model, the constructed models are often presented in other virtual environments transmitted through electronic networks manipulated by others.

> "Mannequins can be transported instantly into the showroom, complete with chairs, tables, statues, and other objects, which can be used as landmarks for the mannequins' walks… their paths could be written in a pre-defined manner utilising the Virtual Reality Modelling Language. This method allows 3D viewing and manipulation over the World Wide Web." (Gray, p. 1998[200]).

Such developments have opened up possibilities for electronic commerce and enhanced interactivities between businesses. Through transmission of personalised body-data it becomes possible to evaluate garment for fitness on individualised virtual models. Distributed access to product catalogues and abilities to manipulate set-ups further enhance possibilities to choose preferred virtual environment etc. Realistic virtual models also provide the business with opportunities to display their designing skills and show what they can do instead of what they already have done. This assists decision-makers in choosing business-partners and can restructure value chain operations and organisation of production.

Software providers in addition to the individual designing tools also offer integrating functionality that allows data from one step to be transferred onto the next[201&202]. Smooth transmissions of product

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[198] Kang, Tae & Sung Kim (1999): "Development of three-dimensional apparel CAD system", in International Journal of Clothing Science and Technology, Vol. 12. pp. 26-38.
[199] www.autodesk.com (2001)
[200] Op cit. Gray (1998), p. 7.
[201] www.lectra.com (2001).
[202] www.gerbertechnology.com (2001).

information and integration of production steps are essential for mass-customised services and automated production operations. Some of the integrating functions include file-transfers and scanning of materials for image transfer, manipulation and application in designing. Tools also support that product catalogues be updated continuously, accessed and shared on-line. Collection management encompasses visualisation of designs, storage of cutting patterns, stocking information, availability etc. However, fully integrated on-line value chains is not likely before some industry-wide standards have been developed that can ensure compatibility of all soft- and hardware. Presently, industry-wide co-operation works to develop a standard for CAD/CAM-files building on the Autodesk DXF-files[203]. Initiatives are dealing with shortcomings related to ill-defined material codes, colour codes, and a lack of general curve smoothing algorithms.

Computer Aided Manufacture

Manufacturing processes are numerous off which some have become digitised and computerised. Computerisations and automations have especially been evident within processes of cutting materials, conveyer systems, in printing and dyeing[204]. As indicated above, designs get produced in virtual environment and cutting-patterns are automatically produced. This pattern-information gets distributed through networks to CAM-technologies, which apply this input for plotting, marker making, cutting, sewing instructions etc. Computerisations of design and selected manufacturing steps have implied a high degree of separation between these steps. Crucial production-information can be transmitted through electronic networks reducing some constraints on geographical distances. As information gets transmitted the design functions get integrated with manufacture through computer-integrated manufacture (CIM), which founds the base for automotive mass-customisation. Digitalisation and other technological innovations have led to smaller minimum batch-sizes, which through integrated information networks assist individualised production[205].

Technological innovations within printing have enabled that dedicated computerised equipment performs individual printing-tasks for small or large production-lots. Colouring of clothing is often performed through large-scale chemical equipment at special sites, but printing of images on clothing has become independent of the large chemical plants. Like printing on paper, the printing on textiles have increasingly been improved and become accessible to most manufacturers due to reduced

[203] Op cit: ”Pattern data exchange standards development revived” (2000).
[204] Byrne, Chris (2000): ”The Industrial and Social Impact of New Technology in the Clothing Industry into the 2000s”, available at www.davidrigbyassociates.com/articles, February 2000, pp. 1-21.
[205] DesMarteau, Kathleen et al. (2000): ”Information Technology Trends Drive Dramatic Industry Change”, in Bobbin, available at www.bobbin.com, November 2000, pp. 1-8.

equipment-needs. Transfer of data from the CAD-programmes governs the printing-operations, which can inform on printing and plotting images at a very high precession. Transfer of CAD-files to the printing-operations also allows for automated printing-processes.

Increasing modularity of the printing task has transformed the working operations. Printing takes can be performed at high precision and with many colours, making it possible to manufacture complex images and patterns. As printing technology has developed, lowering operational costs and increasingly supports small batch productions; it becomes possible to make individualised yet automated printing of clothes. Just as printing has become automated and subject to small-lot production through direct data input from CAD-programmes, so has the knitting and weaving operations that increasingly supports small batch productions too. Weaving and knitting operations have become automated and manufacture of complicated patterns has become possible.

Some of the most evident benefits from automated and CIM processes are found in marker making and subsequently in cutting of materials. CAD-tools generate some pattern data that is transferable to the marker maker, which calculates how the individual pieces of pattern should be placed on the woven cloth in order to maximise utility of materials. Marker making is quite complex processes that get further complicated with special clothing textures and printed images that make the alignment of cut materials very delicate. Marker making functions are dependent on information about the materials, the designed patterns and prior experiences, and calculations of optimal markers are often very complex indeed. Prior to computerisation of this step, it was required that highly skilled personnel should handle this operation, skills that to decades to generate. Instead, computerisation of these processes requires extensive processing capacities, but dramatically speeds up these processes just as materials waste is reduced substantially. Providers of marker making technologies also offer sourcing of processing capacities to their customers[206].

Data from generation of markers is transmitted to the cutting processes, which performs the cutting of materials through automated processes. Supporting the cutting processes, there are processes of spreading materials, stacking them and feeding them to the cutter that may cut single layers or multiple layers at command. Cutting of multiple layers speeds up processes but requires advanced laser technologies to avoid imprecise results. In situations of advanced printed images or partial faults in the fabric it becomes preferable with cutting of single sheets. When production of knitted or woven fabrics

[206] www.gerbertechnology.com (2001).

are followed by process data error reports as in the case of automated fabric production, the error report can be crucial input to the marker making and cutting operations. The situation is different in cases of cutting fabrics with complex images. Despite computerised calculations of images, patterns, markers and cutting procedures, there might occur some deviancies that make the cutting imprecise and stripe alignment impossible. Hence, pattern recognition technologies have been developed that monitors the fabric that is going to be cut, makes continuous adjustments to the cutting lines, and real time alterations of makers.

At present there is not much technology that supports automated sewing. Problems relate to inability of constructing automation equipment that can handle flexible materials and assemble them to 3D-products. Some automation processes have been offered for simple sewing operations, but lean sewing production with monitoring of materials and real time adjustments of materials are yet to be developed. Due to the rigidity in automated sewing processes and their high switching costs, they are only applied for production of large-batch standardised items or operations.

Technological innovations as presented above highlight the integrating aspects of CAD/CAM-files that enable a smooth transmission of files from design steps to manufacturing steps: CIM. The integrating aspects relate to provision of design software with smooth file-transfers and translations into the manufacturing equipments. Many CAD/CAM-technologies have existed for decades, developed on proprietary standards, but have increasingly been equipped with Internet-based interfaces. These interfaces enable that files applying the same software can get distributed on the Internet, facilitating worldwide file sharing and cooperation. Simultaneously with the developing Internet-interfaces the available software also support higher degrees of interactivity between proprietary standards and technologies. Files can increasingly be transferred from one software system to another, however there still exists dire need for refining the compatibility of systems for smoother file-transfers[207]. Some of the integration problems relate to interpretations and transfers of curves and colours, as there are no universal approaches to dealing with positions of points and curve-smoothing algorithms, which is one of the primary tasks of the standardisation work by ASTM (American Society for Testing and Materials)[208]. Their standardisation processes are based on the 14 data-layers of the Autodesk DFX file-format. Just as there are no industrial standards for sizes, shapes and fitness, there are no standards for colours either.

[207] Andres, Karine from Kenzo presentation at ITIT, Information Technologies In Textile and Clothing, Como, Italy, on the file transfers from designers.
[208] Op cit: ”Pattern data exchange standards development revived” (2000).

Interactive work processes have been assisted by the formation of shared workspaces enabled, as files can be transferred from one node to the other, from CAD-system to CAM-system and between different CAD-systems. Shared workspaces provide opportunities for businesses to present photo-realistic graphics or images of developed design or developing processes, which other distributed nodes can interact on. The Internet hence enables a shared virtual workspace for interactive development processes and customised fittings.

Besides the flows of information related to developments of designs and subsequent production steps, software supports process management e.g. through product data management. Management tools not only enable optimisation of operations and logistic processes in production, data supports supply chain management with suppliers. Digitised processes also provide opportunities to monitor sales and initiate automated replenishment programmes, vendor managed inventories, and much speedier production processes[209]. And knowledge sharing functionalities get assisted by monitoring and virtual meetings: web-cams are applicable both for distributed monitoring processes and products and for information sharing e.g. amongst managers or designers in the product development stages.

Electronic Sales

Digitalisation of designs and productions alongside standardisation of communications and developments of electronic networking have enhanced the conditions for widespread electronic sales. The concurrent developments of transaction-mechanisms and matchmaking-processes have been especially important for the development of electronic sales. Electronic sales are greatly assisted by electronic messages that enable exchanges of orders and transfer of finances. Standardisation of communication-structures further enhances integration of production- and order-management with back-office operations and automatisation of sales-processes. Matchmaking-processes are based on generic searches and/or individual searches and readings of homepages etc. Through digitisation of manufacturing processes and application of DMM-technologies it has become possible to display possible products before they get manufactured and for distributed businesses to interact in design-development. Virtual catalogues and presentation of designs on virtual models assist displaying producers' skills and product ranges, and assists buyers' identification of wanted products and suppliers[210].

[209] Forza, Cipriano & Andrea Vinelli (1997): "Quick response in the textile-apparel industry and the support of information technologies", in Integrated Manufacturing Systems, Vol. 8, pp. 125-136.
[210] Regli, William (1997): "Internet-Enabled Computer Aided Design", in IEEE Internet Computing, Vol. 1, pp. 39-50.

Generic searches and manual readings of suppliers' homepages are determining the identification-processes in the virtual environment. Identification-processes are hence based on online information accessible through homepages, identified through search engines, electronic marketplaces or similar services. Through development of electronic brokerage-functions established market-operations may get transformed as virtual presence shifts the barriers for market-reach, processes of disintermediation, alternative price-mediation and the like. Instead of traditional supply-push structures where producers display their products, skills, commitments, services etc. electronic markets may instead communicate the requirements of buyers after which the suppliers can compete on obtaining the orders. Electronic markets may also be the forums where suppliers meet directly with buyers displacing traditional intermediaries, or the markets may be based on auction-like pricing mechanisms where competing bids determine final prices. Importantly, the electronic platform imposes a possibility for economic agents to meet and communicate preferences and options, and for interacting in reaching the final product[211].

In the following sections there is an outline of the present and emerging technologies that support electronic transactions and identification-processes embedded in electronic sales. Following this there will be a section on the available electronic services that supports economic decision-making such as electronic points of sales (EPOS), online market- and fashion-researches etc.

Electronic Transactions

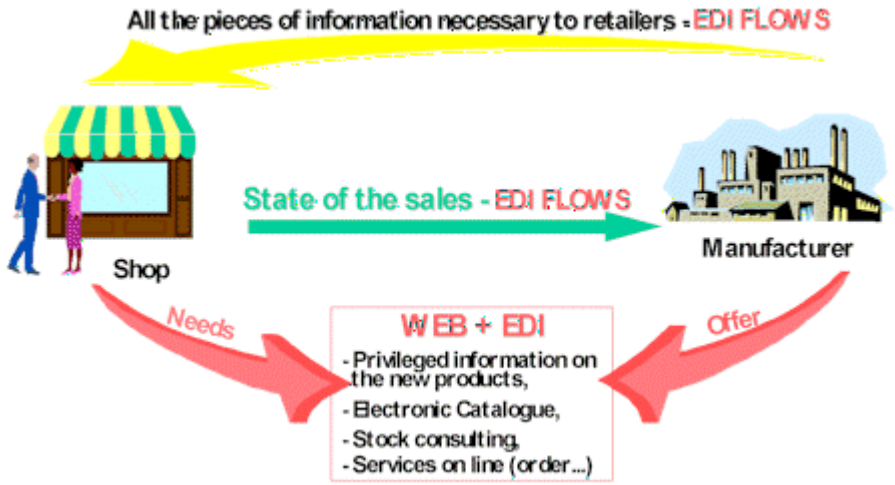
Some of the most widely diffused applications in support for electronic transactions are electronic data interchange (EDI) and electronic funds transfer (EFT). EDI-messages are based on standardised message-structures and codified items, colours etc., which have been applied throughout industry for decades[212&213]. EDI-messaging and electronic transfer of orders and finances precede the development of the Internet and the World Wide Web. Issues of security and the availability of networking structures have been influential for businesses in their choice of EDI-messages and application of networking services from value added network (VAN) providers. The VAN-providers have often provided expensive close-end networks, which have also yielded high levels of security[214].

[211] Bjørn-Andersen, Niels & Knud Erik Skouby et al (1998): "Elektronisk handel og nye organisationsformer" (Electronic Commerce and new organisational forms), Rapport, CBS & CTI, Denmark.
[212] Chatfield, Atkin & Niels Bjørn-Andersen (1998): "Reengineering with EDI", in Kim Viborg Andersen (ed.): "EDI and Data Networking in the Public Sector", Kluwer Academic Publishers, Netherlands, pp. 152-171.
[213] Damsgaard, Jan (1996): "The Diffusion of Electronic Data Interchange", Doctoral Thesis, Aarhus University, Denmark.
[214] Rhodes, Ed & Ruth Carter (1998): "Electronic commerce technologies and changing product distribution", in International Journal on Technology Management, Vol. 15, pp. 31-48.

Introductions of the Internet-based network-structures mediated through e.g. telephone-lines have transformed the competitive environment for VAN providers and opportunities for businesses. Internet-access through telephone-lines is vastly cheaper than the VAN-connections and has a much wider reach, but is also associated with less secure transmission structures, which have been somewhat moderated by introductions of firewalls, encrypted messages and secure subscriber-lines. Some of the most obvious advantages from performing electronic sales based on the Internet-infrastructures are lower costs of networking and larger reach i.e. potentially worldwide access to partners and customers. Whereas the VAN-based EDI-messaging are largely based on propriety communication-standards and -structures, which limits the interoperability of businesses[215], the industry-wide and worldwide Internet-based networking relates to new levels of standardisation. Successful transformation of EDI-messages from VAN-networks to the IP-based Internet communications have been performed, just as extensive co-operation is evident in formulation of international EDI-standards e.g. EDIFACT[216]. Enhanced levels of standardisation not only improve the interactivity of businesses within a given industry; they also enable a more smooth integration of services from other industries such as transportation and finances[217]. High levels of EDI-application indicate smooth interactions between the business of the industry and supporting fields, through which friction and economic losses may be reduced, consequently political institutions have in the interest of economic development given speedy diffusions of EDI very high priorities[218&219].

[215] Brousseau, Eric (1994): ”EDI and inter-firm relationships: toward a standardisation of coordination processes?”, in Information Economics and Policy, Vol. 6, pp. 319-347.
[216] www.edi.dk (2000).
[217] Falch, Morten et al. (1994): ”EDI i transportsektoren” (EDI in the Transport Sector), in Morten Falch et al (eds.): ”EDI – en elektronisk infrastruktur” (EDI – an Electronic Infrastructure), DATE report, No. 6, CTI, Denmark, pp. 69-87.
[218] Tan, Margaret (1998): ”Government and Private Sector Perspectives of EDI: The case of Tradenet”, in Kim Viborg Andersen (ed.): ”EDI and Data Networking in the Public Sector”, Kluwer Academic Publishers, Netherlands, pp. 131-151.
[219] ”Elektronisk handel i Danmark, en national EDI-handlingsplan” (Electronic Commerce in Denmark, a national plan for EDI) (1996), at www.edi.dk available December, 1998, pp. 1-16.

Figure 3.3: EDI-messaging between manufacturer and retail

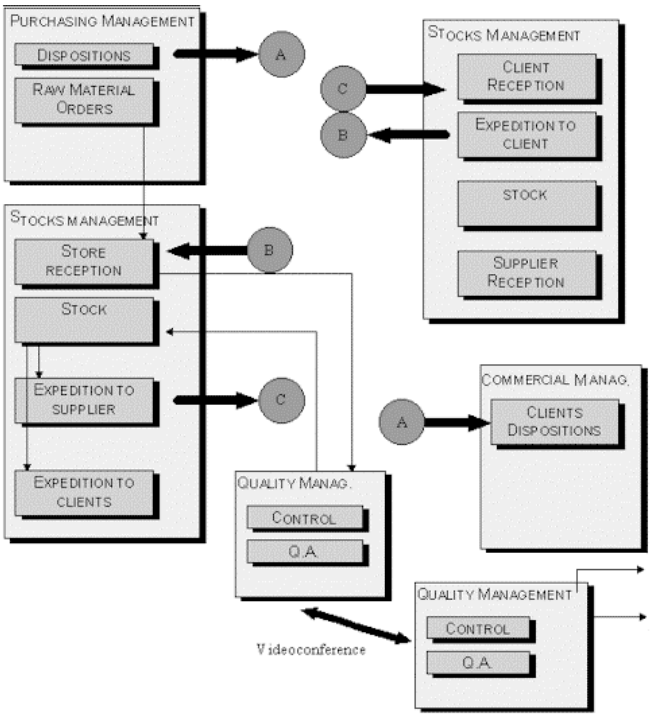


Source: Tex-at-work (2000)[220].

EDI-messaging has especially been useful in situations of well-defined items e.g. in replenishment or ordering of non-strategic standardised items where the item easily can be codified. Less obvious is the application of EDI in product development and frequently changing item-categories. Barcoding of items enable both a unique identification-system and easy reference to the items, applicable in production-processes, in transportation and sales. Through scanning of products of sold items at the EPOS or items taken from stocks it is possible to transmit electronic data on consumption, which enable decision-makers to monitor production-processes and for suppliers to forecast demands. Indeed, through barcoding and scanning of items together with EDI-messaging it has become possible to make efficient vendor-based inventory, where automated processes at the suppliers' monitor consumption and initiated automatic replenishment. Barcoding and shared information-access through electronic messaging supports more than vendor-based inventory as it also enable early warning systems for business partners and improved supply chain management.

[220] Tex-at-work project (2000), on the development of "Telematics in the Textile Clothing Distribution sector, by Aster, Emilia Romagna Technological Development Agency, Bologna, available at www.aster.it/texatwork, April 2000.

Figure 3.4: Telecommunication systems for the Textile and Clothing industry.



Source: Tex-at-work (2000)[221].

Several software tools exist for management of production, inventory and collections, which make it possible to automate most of the process-management and stock-keeping processes[222&223]. Collection management tools indicate which materials and operations are required for manufacture of specific models, and inventory management informs about present stock levels. A part of the automated inventory keeping relates to automated replenishment-programmes that issue an order whenever stocks fall below critical levels, the orders will either be processed automatically or await manual approval.

Electronic Matchmaking

Electronic transactions are supported by EDI-messages and can get automated through applications of software for back-office integration, stock management, transportation, EFT etc. Selecting which firms to interact with electronically may be based on various reasoning such as historic relations, strategic importance or availability of electronic communication structures. The electronic media has increasingly got applied and the potentials for identifying new business partners, and monitoring of existing suppliers and competitors increase[224&225].

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[221] Op cit.: Tex-at-work Project, 2000.
[222] www.just-style.com (2001).
[223] www.lectra.com (2001).
[224] "Use of ICT in Nordic enterprises 1999/2000" (2001), by Statistics Denmark et al, available at www.dst.dk, January 2001, pp. 1-26.

Electronic sales are promoted through virtual stores or homepages with catalogues where the products and skills of businesses are displayed. Homepages offer the opportunity of businesses to display the company profile, products, historic developments, present skills, technologies, capabilities etc. This kind of information assists the potential business partners and customers in determining the trustworthiness and skilfulness i.e. how suitable they are for providing wanted services. Further information on the homepages can relate to availability of products, services and general conditions, which determine the conditions of sales. Homepages to a large extent serves as virtual storefronts where potential partners and customers can monitor availability of products, production processes, skills, services and the like. But the electronic networks also provide the structures and opportunities for businesses to interact; communicate orders and transfer finances through EDI and EFT, production specifications via JPEG and MPEG files, product developments through shared workspaces, and personalised communications through e-mails and videoconferencing. Personalised communications are essential to establish and communicate shared worldviews, as well as for processes of knowledge sharing, control-mechanisms, monitoring and management support. Business to a large degree depend on trustworthy suppliers that provide the needed products or services when needed, and trustworthiness of business partners get communicated through interactions e.g. through the virtual storefront, running communications and historic events. At one hand the virtual store serves the need to visualise the business, it skills and products, on the other hand is serves to generate trust and a channel for personalised communication through which the partners can discuss conditions, specifications etc.

Products get displayed on homepages through virtual catalogues where the customers and other businesses can access visual impressions e.g. as JPEG or MPEG-files. Transmissions of these files enable the person to monitor the designed items, how they look from different angles, in different environments, in different sizes or otherwise individualised settings. Through digitalisation of designs it has not only become possible to display existing product ranges but also to offer impressions of products that has not yet been produced e.g. through alteration of virtual models by new colour combinations, patterns, sizes or fabrics. Hence, it has become technologically possible for the viewers to manipulate the suggested set-ups and identify the fitting of clothing on personal virtual models, to construct own garments through online manipulations etc. Shared workspaces, where a distributed access to a united environment enable shared alterations and development processes. Businesses hence

[225] ”IT i praksis” (IT in use) (2000), by PLS Consult, available at www.pls.dk, November 2000, pp. 1-15.

experiences new interfaces with customers and partners where designing and potential products increasingly can be transferred to customers, who may alter the proposed designs, and where orders increasingly will be received before production processes are initiated. The distributed access to homepages and small-batch production-structures further supports the possibilities of mass-customisation processes.

Electronic brokerage has been essential to the success of electronic sales. Brokerage functions are found within numerous services and with a multitude of functionalities. At one end of the scale there is online business-catalogues where firms are categorised by function or product-codes, searches will hence reveal the hits on particular codes[226&227]. Similar functionality is found in search-engines where the engine will search documents for specified words or combinations thereof. Hits on keywords or product categories are seldom sufficient for business to identify partners; they need more detailed information and hence more sophisticated search-processes based on standardised business information or product codes. However, there exist at present no universal presentation or coding standards that describe neither which information that should be revealed on homepages nor how they should be presented. This makes search-processes across different homepages on business information, products and prices extremely difficult, only if information get structured or codified identically it becomes possible to make satisfactory generic searches. Initiatives have been taken towards constructing industry-wide XML-codes for different pieces of information based on established EDI-standards. Compared to the HTML-like EDI-structures, XML-coded documents describe content not layouts, hence searches based on specific pieces of information are enabled if a relevant and industry-wide XML-code exists. Further standardisation-programmes and improved search engines could also enable searches based on non-codified images and product attributes, the potentials from identify specified colours, patterns or pieces of materials are evident to the textile and clothing industry[228&229].

A crucial part of generating electronic sales is related to the matchmaking procedures that are found in electronic marketplaces. These marketplaces are often constructed as virtualisation of known business concepts found in the physical world. Hence, marketplaces that assist business-to-business (b2b) or business-to-customer (b2c) interactions hold some form of brokerage and pricing mechanisms. Like walking around in business-centres or at business-exhibitions the person may travel the virtual space

[226] www.europages.com (2001).
[227] www.fashion-tracer.com 2001.
[228] www.topicmaps.org 2001.
[229] www.comon.dk 2001.

and identify potential products and suppliers. Prices get settled trough conventional price tags, or through auctioning where suppliers or buyers compete. Electronic markets frequently provide a set of additional services that assist the transactions. B2c marketspaces often provide structures for enhancing security for payments, physical distribution of products, and provision of authenticity statements that declare customers or providers trustworthy. The trustworthiness is also important issues for the b2b marketspaces. These spaces have developed either for non-strategic provisions where e.g. the office equipment is bought, or for strategic provisions where suppliers register and receive orders. These structures are frequently related to some non-virtualised processes that prequalifies suppliers and to dedicated software that ensures the compatibility of systems.

Electronic matchmaking is a potent tool that has developed rapidly in recent years notably as b2b electronic markets. Besides the identification of potential partners the businesses need to decide if the identified potential partners are suitable for further co-operation and interaction. Decision-making on these issues depends on formation of shared worldviews, which partly get communicated through homepages where the business can present past events, historic developments and present performances, and partly by through personal communications. Worldviews encompass the subjective and social perception of the environment, and are essential for determination of trustworthiness etc. As communications of worldviews are quite complex they depend on media-rich communication-structures[230]; frequently personal meetings serves these purposes, but increasingly DMM-technologies can support virtual meetings through videoconferencing. Through online communications the business partners can hence not only corporate on product developments, exchange production know-how and the like, but also engage in social relations that establish levels of trust, expected commitments, expected results and predicted mediations.

Other electronic services

Electronic sales and economic decision-making are supported by many more technologies than those technologies that enable electronic transactions and virtual matchmaking. Economic decision-making hinges on a wide span of information sharing and combined knowledge formation, off which transacting and matchmaking are only a few. Other important aspects include analyses of markets, fashions, and production- and information-technologies. Market-analyses are important for precise demand-forecasts and decisions on how much and when to produce. Trend-analyses are

[230] Daft, Richard & Robert Lengel (1986): ”Organisational Information Requirements, Media Richness and Structural Design”, in Management Science, Vol. 32, pp. 554-571.

correspondingly essential in determination of what to produce, just as information of production and information technologies provide knowledge on how to produce and organise production-structures.

Market-analyses provide the decision-makers with information about the demand situation, partly based on own data and partly on special provisions by other partners or service providers. Own market-analyses relate to known sales in different markets, historic sales data, known segments etc. Though these analyses are based entirely on belabouring of information and hence separable from the production processes, they are highly specific to the firm and have only been outsourced or transferred at a limited extent. However, with increasing networking and value chain structures the individual firm seldom possesses all the required data for neither thorough analysis nor the resources, instead information get shared between the business partners. Emphasis has been put on development of smooth information-sharing technologies for value chains, which support a direct information flow of sales and production data. Barcoding and scanning of sold items at EPOS provides the value chains with speedy, accurate sales-data, and continuous production updates and distribution of data support the management of supply chains.

Market-analyses not only relate to known markets and products but equally well for less familiar environments such as long-term future developments and new markets. Several institutions exist that provides such information and analyses e.g. the CITER in Carpi, Italy or the Danish Employers Organisation, who increasingly provide these general information services online[231]. Some of their information products relate to analyses of future economic and demographic developments of existing markets but also relate to the emerging markets in Eastern Europe and Asia[232]. It has also become possible acquire special analysis online that targets the situation of the acquiring firm e.g. by the European Textile and Clothing Observatory, these are prohibited expensive. Important parts of the market-analyses are to identify the commercial strategies of partners and competitors in order to learn and respond. This information is partly retrievable from the market-analyses, news reports and from the homepages of competitors and partners.

Fashion-analyses are equally important to the decision-maker on what to produce, and numerous institutions have emerged that provides fashion-analyses as magazines, reports, newsletters etc[233]. Like the market-analyses, the fashion-analyses can be perform by the individual businesses, corporately in

[231] www.citer.it (2001).
[232] http://clothing.tradeworlds.com (2001).
[233] www.textileweb.com (2001).

the chains, or be provided by third-party institutions, but in contrast the fashion-analyses depend much more on visual impressions. Fashions develop rapidly depending on the economic development, the industrial performances, and the designers' trends, which have led to institutionalisation of fashion presentations. Traditionally the fashions are related to the 4 yearly seasons, but individual firms may change their collections whenever they want. The seasonal changes in weather have inspired textile producers and clothing manufacturers to develop new designs that satisfy the emerging needs of customers, and the most fashionable designs are presented at shows in Paris, Milan, London and New York. Besides the trend-setting high fashion shows there exist a myriad of national and local fashion shows where the local manufacturers present designs. Through diffusion of DMM-technologies and improved capacities of electronic networks, online-presentations increasingly support the fashion demonstration. Virtual presentations of designs are partly mediated as online media-streams where fashion shows have been filmed and the get transmitted through Internet-structures. And partly the fashion products get visualised through JPEG and MPEG-files from virtual stores.

Specialised analyses are provided on the development of new production and information technologies, and online-services continuously provide updates e.g. Bobbin[234]. Fashion shows and product-displays indicate the present barriers to production technology and the newest product innovations e.g. for intelligent clothing. Intelligent clothing includes items with additional functionality included e.g. mobile telephony, MP3-player or GPS (General Positioning System, which through numerous satellites enable a precise location on earth). Market-analyses such as news reports indicate latest organisational trends and restructuring attempts e.g. formation of new alliances or entry to new markets. Obviously, there also exist a range of sources to more direct information on new production or information technologies such as dedicated exhibitions and homepages by major technology suppliers.

Summary

Digitisations of processes and technological developments have had great impact on the operations in the textile and clothing value chains. Probably the most evident transformation of operations has been identified with the design processes where the entire process can be digitised. Inputs to the design processes comes with scanned images, retrieved data or shared files, which become manipulated at workstations and in shared workspaces. Developments in processing and transmission abilities together with increasing compatibilities of software programmes enable enhanced levels of file

[234] www.bobbin.com (2001).

sharing, process-integration and 3D-modulation. Notably the video-objects in the MPEG-4 coding-standards and the multi-layer virtual environments in Autodesk are promising for enhanced 3D-modulation. The more photo-realistic the presented designs the better the tool for decision-making on which designs to choose and the bigger the abilities to display skills and sell products before manufacturing. A promising feature that still requires refinement is the virtual draping, which is based on 3D-modelled garment on moving virtual dummies. Computer-requirements are especially high, when realistic features are wanted on fabric movements, fabric collisions and fabric visualisation, and when the operations of the 3D-dummy require interactivity with viewer.

In addition to the technological developments that foster increased interactivity in product-developments, tools also emerge that assist the commercial processes, identifications of new businesses and markets, and for mass-customisation processes. Transaction processes are assisted by EDI and EDIFACT-messages, which increasingly are transferable from proprietary networks to Internet-based transmissions. Online sales and ICT-integrations with retail enable that personalised measures may be transmitted to manufacturers and subcontractors for customised provisions. Brokerages functionalities also improve notably with definitions of industry-wide XML-codes for products and attributes. Electronic marketplaces develop, which enhance the market reach, and specialised information services become available including to market, fashion and technology analyses. An emerging technology that has commercial potentials is the web-cameras that support both videoconferencing and personalised communications, and monitoring and control functions, which enable more, distributed control, enhance feedback processes and facilitate more outsourcing.

3.5. Applications of DMM-Technologies

This section offers an impression on the application-level of the different ICTs and DMM-technologies in the Danish textile and clothing industry. Emphasis is put on the development of the electronic infrastructures in Denmark, their capacities, and the applications of some ICTs and DMM-technologies in production and communication. Whereas numerous accounts have been given on the networking development in Denmark and on the application of ICTs in support for electronic commerce, little public statistics are available on the applications of hard- and software in production. Accounts on the applications of CAD/CAM-technologies and maturation of homepages are hence based on own research conducted in 1999-2001. The results are referred to below[235].

[235] See appendix B for a more detailed outline of the statistical analyses.

Networking Technologies

Developments of the electronic infrastructures have gained momentum in the past decades, which is partly related to a higher political priority and to more public and private finances put into the infrastructures. However, technological innovations have probably contributed most by constant upgrading performances i.e. capacities and accesses. This has together with the increased political attention led to alteration of tele-markets institutionalised through a range of legislative initiatives. Legislation have contributed to restrictions on the former tele-monopoly, liberated access to markets for other operators, and been supportive in allowing competing access-technologies that increasingly support diffusion of broadband connectivity to all in Denmark[236]. Legislative initiatives have resulted in restructuring of the competitive environment in the telecom-industry; a multitude of operators has emerged, competing network-structures have been introduced, and prices have diminished at the same time as the portfolio of available services has expanded. Domestic market-structures have altered from being a market with a handful of regional operators that have merged into a domestic monopoly, and lately become exposed to international competition from the early 1990s. Alongside the increased legislative activity the political interests have been expressed in numerous reports and analyses as well as increased public funding. Likewise, initiatives have been taken that attempt to place the public sector in the forefront in implementing ICTs and in providing digitised services[237]. Latest evidence has been public subscriptions to the business-to-business marketplace Gatetrade.net[238].

Danish households and businesses increasingly experience new, better and cheaper modes of access to the electronic network[239&240]. Recent developments in access-technologies and generally high levels of Internet-connectivity put Denmark amongst the leading networked countries in the world, and in absolute elite in Europe[241].

> "By all the standard indicators, Denmark stands up extremely well in comparison to other leading countries with respect to progress in telecom reform. Its national telecom market development, and the service coverage of its basic telephony and mobile services rank near the best in the world, along with other Nordic countries. Denmark's prices rank almost as well." (Melody, 2000[242]).

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[236] www.tst.dk (2001).
[237] "Beskrivelse af digital forvaltning i Danmark, Sverige og Norge" (Description of digitised administration in Denmark, Sweden and Norway) (1999), Forskningsministeriet (Ministry of Information Technology and Research), available at www.fsk.dk, October 2000, pp. 1-59.
[238] www.gatetrade.net (2001).
[239] "Telestyrelsens rapport om nye adgangsveje til netværkssamfundet" (Report on new accesses to the network society by National Telecom Agency, Denmark) (2000), available at www.tst.dk, November 2000, pp. 1-31.
[240] "Nye muligheder for højhastighedsaccess, Telestyrelsens accessredegørelse" (New options for highspeed access, access narration by National Telecom Agency, Denmark) (2000), available at www.tst.dk, November 2000, pp. 1-61.
[241] "eEurope 2002 Impact and Priorities" (2001), Report for the European Commission, available at www.europa.eu.int, March, 2001.
[242] Op cit: Melody (2000), p.17.

Access-technologies such as ISDN have become cheaper and more widespread, and its successor ADSL is gaining momentum too: new targets set by TDC are that by 2002 95 percent of all households will be able to apply the ADSL-technology, and 90 percent with a minimum capacity of 512 Kbps[243]. This requires a substantial upgrading of the national telephony network and digitisation of local loops. Presently, there are 3 companies in Denmark that offers ADSL connections: up to 2 Mbps downstream and 512 Kbps upstream. Competitions and technological innovations on the fixed-line telephony have meant a upgrading of services and capacities, just as the unit costs of telephony are decreasing. Tariffs are increasingly transformed from time-dependent pricing to size-dependency, and recently a flat rate, independent of time and usage, has been introduced for ADSL-connectivity.

In a response to failure in obtaining one of the licences for establishing FWA infrastructure in Denmark TDC has prioritised a fast upgrading of the telephony networks to support ADSL-connectivity[244]. Indeed the distribution of 7 licences to 5 different firms in late-2000 have been a conscious attempt by the regulatory to generate competition at the local loop i.e. the accesses for private households and commercial users to the backbone telephony network. Some of the emerging FWA-access possibilities will support commercial needs by providing capacities in excess of 30 Mbps, and other solutions will target the private customer providing only 256 Kbps both-ways. However, the connectivity equipment is still quite expensive (about 20.000 DKr. for the commercial solution[245]) and is not expected to offer full national coverage. A restricting parameter for the diffusion of FWA-connections is the limited coverage by the FWA-transmissions at 8 to 10 km.

Other developing access-technologies relate to the cable-net, which is primarily provided by two operators in Denmark. Cable-TV covers about 60 percent of all households notably in urban areas, the offered technology allows for transmissions at 512 Kbps. Another fast growing access-technology is mobile telephony, which is expanding rapidly in reach, services and diffusion, and could develop even further with construction of the UMTS infrastructure. The present 2nd generation GSM telephony has got quite diffused in Denmark who is amongst the world leading users with high penetration levels.

[243] www.computerworld.dk (2001)
[244] www.computerworld.dk (2000)
[245] www.pcworld.dk (2001)

Compared to other countries and regions Denmark is performing very well on Internet-connectivity: 37 percent of the Danish population was connected to the Internet in January 2001[246]. This puts Denmark in the worlds' top 6 only outperformed by the other Nordic countries and Canada, and tightly followed by e.g. South Korea and Singapore. Generally, the regions that do best on electronic networking are Western Europe, Northern America and the Asian tiger-countries. Indeed the Asian countries of Singapore, Hong Kong, Taiwan, Korea and some major Chinese cities do very well indeed on Internet-applications[247]. The high Internet-penetrations enhance abilities for a wider market-reach, direct communications with customers and businesses, disintermediation and mass-customisations. National provisions of broadband access through cable-TV networks and xDSL-lines, which is estimated to reach almost 40 percent by year 2005[248], promise increased DMM-file transferring in support for commercial activities e.g. virtual product presentations.

Digitised Production and Information Technologies

There can be no doubt that machinery for textile production and clothing manufacture increasingly get linked in electronic networks. Computers are widely used in the design processes, and the CAD-files are transmitted to the manufacturing machinery. CAM-technologies also get digitised and dependent on electronic connectivity, and production organisation is governed increasingly through computerised control systems. CAD-technologies have been important tools for all businesses that design or produce textile and clothing, and these digitised technologies have been applied and networked since the early 1980s. CAD-technologies have been diffused to about ¾ of the industry, and hence this rate of diffusion exceeds than that for CAM-technologies[249]. Concurrent to the diffusion of CAD/CAM-technologies, these technologies increasingly get networked with other applications both inside the firms and with other enterprises.

Diffusions of computers, telephones and faxes have nearly reached 100 percent for all businesses. Abilities to work and be mobile are increasingly supported through application of portable PCs and mobile telephones[250]. Portable PCs seem especially relevant for sales personnel who travel around and need access to centralised information e.g. through on-line connectivity to the main company. These applications inform about customer-updates and production-status, calculates requirements and costs etc. The functionality found in WAP-technology (Wireless Application, which incorporates an

[246] www.emarketer.com (2001)
[247] www.emarketer.com (2000).
[248] www.peasy.dk (2000).
[249] Based on approximately 25 responses from surveys and interviews, 2000.
[250] Result form own survey on the textile and clothing industry (2000).

interface to the Internet on mobile telephones) is presently of limited interest, and has only got applied by a few companies[251]. Mobile applications are also relevant through GPS-services where it becomes possible to position specific items and shipments. These services are offered by the transport sector and used by textile and clothing. An important application in support for business-interaction is the EDI and EDIFACT (international EDI-standards) messaging, which have got diffused to large segments of Danish industry. Indeed, Denmark is the leading Nordic country when it comes to diffusion of EDI-structures, and hence is in the world elite. 39 percent of all Danish businesses applied EDI in 2000[252], and EDI-supported turnovers amounted to 60 billion DKr. compared to only 12 billion DKr. from Internet-based b2b e-commerce, and b2c e-commerce only contributed with approximately 2 billion DKr[253]. EDI-based transactions are expected to increase even further as international and industry-wide standards get established as EDIFACT and EDITEX (an international EDI-standard especially applicable for the textile and clothing industry), and as the Internet increasingly is enabled to support these transmissions. EDI has first and foremost been diffused to large enterprises, and within the sectors of wholesale and business services e.g. banking[254]. Local patterns of diffusion are in the case of wholesale coming from the sales-organisations compelling suppliers to adopt EDI. The wholesaler holds benefits of reduced operational costs and increased efficiency, and future advantages would stem from improved sales-forecasting, data-accuracy from EPOS, back-office integration and consequently reduction in errors and liberation of resources for other tasks[255]. Advantages from digitised processes are related to application of scanners, which also have become widely diffused.

Table 3.2: Electronic sales in Denmark 2000-2001.

	EDI 2000	**Internet 2000**	**Expected Internet 2001**
B2B Turnover, in billions DKr.	60	12	-
Total access	39 %	81 %	84 %
All homepages	-	52 %	66 %
Industrial homepages	-	56 %	70 %
Tex. & cloth. homepages	-	60 %	74 %[a]

Source: Statistics Denmark 2001 and own researches 2000. Note: a) own estimate.

[251] Op cit: Own survey, 2000.
[252] Op cit: "Use of ICT in Nordic enterprises 1999/2000" (2001).
[253] www.computerworld.dk (2001).
[254] Henten, Anders & Knud Erik Skouby (1993): "EDI Development in Denmark", CTI-report, Vol. 2, pp. 71-81.
[255] Op cit: Damsgaard (1996).

Increasingly the Internet gets applied to support business-processes. IP-telephony is still under development just as videoconferencing is maturing as a media for interaction. Both hold promising prospects e.g. through low IP-telephony costs and saved travel time, however both technologies await large-scale penetrations. Acceptable standards of videoconferencing technologies are still quite recent, and only a few larger companies in the textile and clothing industry apply these technologies.

Despite the modest turnovers generated from electronic sales in Denmark, Internet-based storefronts and homepages have become evermore-important means for businesses to present themselves and their products. Combined with reducing costs of connectivity and increasing familiarity, the Internet have become more diffused than the EDI-technologies; 81 percent of all business have Internet access in 2000[256]. Whereas larger companies primarily have applied EDI, Internet has become diffused equally by both large and small enterprises. Diffusions of homepages are also quite high as 52 percent of all business had a homepage in 2000, which is expected to rise to 66 percent in 2001. Diffusions of homepages are also evident in industry as the corresponding figures are 56 for year 2000 and 70 for 2001. Generally the larger companies have applied more ICTs and DMM-technologies than the smaller ones, but despite being largely composed of SMEs the textile and clothing industry is doing comparatively well as homepages have been introduced by over 60 percent in late 2000[257].

About 10 percent of homepages facilitated direct sales in 2000, but homepages hold many other attributes and support many other functions than electronic sales; most importantly the homepages present a gateway to communicating with the company, access to information about products and business profile, and access to services. Danish companies often view their homepages and the Internet as communication tools, and e-mails not only support existing communication-forms as telephony and faxes, but also increasingly replace them[258]. Homepages also serve the needs to promote products and companies, give special information access to partners, provide after-sales services, and promote direct sales. The Internet is also applied to search for information on markets, business-partners and competitors, just as it provides a tool for communicating and transfer forms to the public administration, and to transfer money through links to banks. In 2000 the businesses applied Internet-

[256] Op cit: ”Use of ICT in Nordic enterprises 1999/2000” (2001).
[257] Own research (2000).
[258] Rask, Morten (1999): ”Nordjyske virksomheders anvendelse af Internet” (The application of Internet by enterprises in North Jutland), Centre for International Studies, Aalborg University, pp. 1-34.

based information processing for general information search (88 percent), financial transactions (69), dealing with public authorities (58), competitor analysis (42), and recruitment of personnel (29)[259].

Homepages are important more for their information processing and communication abilities than their direct support for electronic sales, and their targets encompass both private users and other businesses. Looking at access and use by private users, it becomes evident that Denmark holds a great potential for electronic commerce: over 50 percent of Danish households have Internet-access, only the Netherlands and Sweden score better on this account[260]. More than one third of Danish Internet-users buy products online, but users seem to do much more online shopping i.e. information search and looking at products, than actual buying[261]. Same research on international conditions reveals that shopping for or buying clothing hold a very high share; only the buying of travels and books or music are more evident activities.

Textile and Clothing Industry

Textile and clothing industry show good diffusion rates of homepages (60 percent in 2000) and e-mail (78 percent)[262]. However looking at the different homepages, it becomes apparent that they suit different needs and are based on very different visions: homepages display divergent resources and targets. Generally, the larger companies have the most extensive homepages where they provide much more information than average, less ambitious businesses only provides images of the clothing and hence merely offers virtual catalogues. Generally the Danish companies apply homepages as virtual business cards and as information and communication channels, but they also attempts to improve their images and attempt to create a sense of proximity or direct connection to customers[263].

Often the homepages display information about the company, where it is located and how to contact them, which is basically just a means to generate a virtual presence: businesses want to let other know that they exist and are able to handle ICT-based communication e.g. Anini[264]. This kind of information is primarily targeting other businesses that know about their existence and business profiles, and hardly requires any updating. It is more frequent so see homepages that only display product-

[259] ”Danske virksomheders brug af IT 2000” (The application of IT by Danish enterprises, 2000) (2001), available at www.dst.dk/it, April 2001.
[260] Op cit: ”*e*Europe 2002 – Impact and Priorities” (2001).
[261] www.computerworld.dk (2000).
[262] Own research of 263 companies (2000).
[263] Op. cit: Rask (1999)
[264] www.anini.dk (2000).

information e.g. Cd-company[265]. This kind of homepage primarily provides product-profiles and special information about their attributes, and presumes that the potential customer or business-partner know about the company profile, or they expect that the branding-value of their products are so evident that it requires no further information about the company.

It is obviously more demanding to make information updates on the products than on the company itself, mostly businesses offer both as over 50 percent of the homepages displays both company and product profiles as e.g. Capacity[266]. This kind of homepage not only informs about the company and its strategies, it also describes or visualises the produced services or products, and finally offers a opportunity for further communication i.e. e-mail address. Often these pages target other businesses, the press etc., other sites primarily target private customers e.g. InWear[267], whereas some manage to have an even wider range e.g. Belika Strikvarefabrik[268]. There seem to be a gradual acceleration of the information levels provided: the longer the homepage has existed the more comprehensive it becomes.

Besides offering an increasing amount of business-information the homepages also improve the levels of services. The offered services include information on production conditions, environmental standards, design priorities, input for individualised designing, sales channels and online shopping facilities. Some of the more comprehensive illustrations are Kansas who offers opportunities to compose individual colouring of clothing[269], or George Jensen Damask that informs about designs and shopping abilities, just as they offer abilities to provide own designs[270]. Less than 5 percent of the investigated textile and clothing companies in 2000 offered direct sales, which is well below industry average. It is not only physical companies i.e. brick-and-mortar companies that has gone virtual i.e. click-and-mortar, some entirely virtual companies have emerged. These firms exist in the virtual environment and provide online sales of textiles and clothing, and hence offer an alternative distribution channel to the manufacturers. These kinds of electronic companies offer alternative sales related to out-of-season models, second class products, or products from new manufacturers, and hence they do not pose any immediate threat to the established sales channels. However, due to the limited performances of b2c electronic sales in Denmark, some of these companies have run into finical problems e.g. boo.com and haburi.com.

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[265] www.cd-company.dk (2000).
[266] www.capa.dk (2000).
[267] www.inwear.dk (2000).
[268] www.belika.dk (2001).
[269] www.kansas.dk (2000).
[270] www.georgjensen.dk (2000).

Growing potential for b2b electronic commerce has meant the introduction of numerous electronic marketplaces and other electronic matchmaking services. Electronic markets have been introduced that covers one of the regions: Europe, Asia or America, but more specialised information services also exists e.g. italianmoda.com. Some pays attention to providing product and company information e.g. through virtual trade shows[271], whereas others provide a trading forum where single purchases can be made. The latter often offers structures for product description and visualisation and they provide a pricing-mechanism e.g. auctions. Other advanced electronic marketplaces offer matchmaking services based on the skills and use of technologies by different companies, which enables identifications of businesses that can integrate their production processes through smooth CAD/CAM file-transfers. The major technology providers e.g. Gerber and Lectra have initiated such services, where businesses can identify potential partners that apply specific technologies. The electronic marketplaces like other information providers offer specialised information about markets, technologies, product innovations etc. Presently there are no electronic marketplaces that target Danish textile and clothing industry, but initiatives have been taken to develop a Danish industry-wide Internet-portal by the Visholm Group[272]. The employers' federation also offer special information online[273].

Summary

All indicators show that Denmark is doing very well on electronic networking and holds great potential for electronic commerce. Technological developments and increasing competition on accesses to the networks have been assisting wide diffusion of Internet-connectivity, packet-switched connectivity for large data transmissions, and good pricing systems: ADSL has become highly profiled in Denmark and introduction of fixed pricing mechanisms irrespective of actual usages renders this a cheap commercial solutions. ADSL connectivity like the television cable networks provide asymmetric connections, which are suitable for accessing Internet-based information, but ill-suited for online interactivity. This leaves businesses and consumers with lower bit-rates from ISDN-connections, which have become widely applied, or alternatively with broadband xDSL-technologies or FWA-connections, which are still under development, quite expensive and not that relevant to private users and small businesses.

CAD/CAM-technologies have become widely applied by industry, just as businesses offers information and interactivity through homepages, e-mails and electronic sales. And customers have

[271] www.ivts.com (2001).
[272] www.visholm.dk (2001).
[273] www.textile.dk (2001).

wide access-possibilities to the Internet, which opens a direct link to customer information, requirements and data-input for personalised fittings, but only few companies have as yet offered online personalisation of clothing. Mobile technologies are not essential to the industry. Mobile telephony is generally becoming diffused in Denmark, but the industry has only little commercial applications. Another form of mobility is found with the usages of Internet-connected portable PCs, which increasingly get applied: sales-representatives gain a distributed access to company-information and customer-profiles. Technologies like web-cameras and videoconferencing equipments are not that diffused, probably due to its novelty and mediocre video/audio provisions on ordinary telephone networks.

3.6. Conclusions

This chapter has contributed with an outline of the digitised production and communication-technologies applied in the Danish textile and clothing industry. Simultaneous developments and improvements in computers and network-abilities have continuously shifted the boundaries for what can be digitised, distributed and manipulated in virtual environments. These developments have enhanced the potential for commercial applications, just as they have contributed to lean production structures. Some of the important aspects of developments in ICTs and DMM-technologies, which have been outlined above are the electronic support for product presentations and alterations, business searches and identifications, and for personalised business communications. CAD/CAM-files have been applied for long and shared workspaces are coming forth as features that are important for online product-presentations and interactivity with customers. Business-identifications are enabled through numerous tools as homepages, Internet-based searches, XML-standards etc. Matchmaking services develop alongside specialised information services. And importantly, these technologies support business-integration and personalised communications, the former as EDI-based files and the latter as e-mails. Videoconferencing is an emerging tool that has large potential for distributed personalised communication, but only little present application. Together these features are very promising in enabling an improved communication both up and downstream value chains, enabling transformation of supply-push markets into demand-pull markets, and increasing the socio-economic efficiency of the industry e.g. international division of labour, lower costs and reduced discrepancies between demand and supply.

Computers continuously upgrade through improved processor-abilities, which are important in order to obtain increasing distributed processing-abilities required for DMM-files and online interactivity.

Different components of DMM-files are subject to differing sensitivities to data-losses and delays in transmissions: texts/data is quite sensitive to losses whereas audio and video are relatively immune. Interactive applications like telephony, videoconferencing and shared workspaces are very sensitive to delays, which is not a major problem to transmissions of most texts. Further, text/data streams in contrast to video and detailed graphics do not require much bandwidth in transmissions. Different and somewhat substituting network-technologies and services have emerged, that satisfies these various requirements. Text/data streams and ordinary voice telephony are mostly transmitted through circuit-switched public networks with low bandwidths but high accuracy and speedy delivery for smooth interactivity. These solutions are unsuitable for large data-transmissions e.g. video and graphics, which instead get based on packet-switched transmission-structures, that offer larger and more flexible bandwidths. Simultaneous and symmetric access to data is crucial to some DMM-applications: for videoconferencing and shared workspaces. These requirements increasingly become satisfied through applied xDSL accesses to the public telephony networks and other packet-switched structures.

Computer-powers have continuously increased concurrently with the increased requirements for detailed, photo-realistic visualisations, interactivity etc. Increased realism in model-presentations is obtainable through intensive calculations of clothing algorithms, which require extensive computer capacity. Tradeoffs are obvious in the computerised presentations of materials: reduced levels of details and realism decreases computing requirements. Interactivity is an important element for the presentation of virtual models: presentations of products through virtual catalogues enable the viewer to manipulate elements of the presentation e.g. setting of the virtual show, personalised measures and fitting, turning and twisting the virtual dummy etc. These functionalities get enabled through multi-layer modelling and through improved transmissions techniques e.g. through MPEG-4 compressions. More direct interactivity is required for shared workspaces where a distributed manipulation of objects gets enabled. These work-processes require symmetric data-transmissions and often also an additional line for audio communications. Similar requirements are found in videoconferencing where distributed nodes communicated through audio and video, and often require additional data transmissions of documents etc. Both the interactive workspaces and videoconferencing applications require high bandwidths and are sensitive to symmetric transmission abilities without delays.

CAD-programmes increasingly assist value chain integrations. Designs increasingly get manufactured and manipulated in virtual 3D-environments, and distributed interactions with customers and suppliers are facilitated. In addition, the CAD-programmes provide files for manufacturing processes e.g. cutting-patterns and printing instructions, applicable for the CAM-technologies. Substantial parts of

CAD-programmes have been developed decades ago and based on proprietary standards and file systems. Increasingly their functionalities get upgraded through developments of Internet-based interfaces and standardised translations of files, which mean that the CAD-files can be read by universal Internet image- and video-viewers, and data from one software package can get transmitted to another without losses. Production processes are especially influenced by these CAD/CAM-technologies: computerised processes increasingly support design-processes, image-files get imported, edited and visualised through distributed structures. The various production steps get integrated through electronic networks, even when physically distributed.

Concurrently with the developments that enable distributed, integrated production-processes, the digitisations of processes and applications of DMM-technology enable altered commercial and matchmaking processes. Electronic sales have been assisted by applied ICTs such as EDI-messaging, which have enabled back-office integration of business-processes, and by Internet-searches based on keywords or codes. Notably the information sharing ability founded in EDI-messaging has great commercial potential in sharing customer information, mass-customisation and targeting of customers. Increasingly the DMM-technology and introduction of XML-codes open up opportunities for other more detailed search processes and for enhanced information and communication processes. Through development of industry-wide standards it becomes possible to make searches on colours, designs, patterns etc., and through applying DMM-files on homepages it becomes possible to display skills and product abilities: presentation of possible products before manufacturing. Realistic visualisations of potential products enable that entirely new industrial structures and processes will emerge: buyers can evaluate deliverances and skills before ordering, just as production organisation increasingly will support individualisation and production on orders.

Not only can the compositions of production cycles be altered, it is also highly likely that new value chains get structured. New identification processes based on key words, images etc. will enable that new business partners can be identified. Outsourcing and other economic interactivity with new partners depend on their skills and trustworthiness, which get communicated through matchmaking services and homepages: matchmaking processes are offered by electronic marketplaces and the major technology providers who informs about technological skills of companies that uses their technologies. And homepages increasingly displays skills, business and product information as well as they enable interactive forums for design development and communication. Videoconferencing enables new levels of communication for knowledge sharing, partner-evaluation, for monitoring and control-processes, and together with shared workspaces for interactive product developments. In addition to the emerging

electronic markets and other online matchmaking services there have emerged an increasing amount of online facilities for the textile and clothing businesses: online provisions of information on fashion trends, market developments, technological and organisational innovations etc. Electronic information and communication hence hold the potentials for distributed but integrated, lean productions, for integrated back-office operations, for interactive product developments and individualisation, for outsourcing of production and services, and for new identification processes, which all contributes to a restructuring this industry. With the globalisation of file transferring, the potentials for making value chains global also increase.

Chapter 4. Textile and Clothing Industry

4.1. Introduction

4.2. Industrial Characteristics

- Technological Innovations
- Regional Developments
- Summary

4.3. International Trade

- Trade Evidences
- Textiles
- Clothing
- Summary

4.4. Danish Textile and Clothing District

- Historical Contingencies
- District Structures
- Internationalisation
- Summary

4.5. Conclusions

4.1. Introduction

International trade in textile and clothing has grown rapidly during the past decades, outpacing the growth in global production. These developments in international trade have numerous causes and implications to the national industries. The impressive rates of growth in international trade at one hand reveal that products increasingly get differentiated e.g. leading to higher intra-European trade, and on the other hand that international division of labour get more developed: more functions get outsourced to low-cost countries.

International competitiveness of various industries is based on their compositions of localised production-factors and -structures[274]. Abundant natural resources impact Australian and South American positions on the world markets for wool. Plentiful labourers at low costs are important to Eastern European countries and some Southeast Asian countries, whereas Denmark, other Western European countries and North America instead compete on highly skilled labourers and mechanised processes[275]. Industrial compositions and supporting industries are also important e.g. petro-chemical industries in Germany, and large-scale manufacturing plants in Poland. Networking is also important related to localised outsourcing, improved flexibility and shared information, and supported by regional institutions in industrial districts. And technological applications are also decisive for the competitiveness: mechanisation has led to substitution of labour by capital and mass-producing entities, and digitisation of administration and production-processes and applications of ICTs and DMM-technologies enhance production-speed, quality and developments.

Industries develop through time subject to how these techno-economic factors interact with the socio-political sphere[276]. Early economic theory indicates uniformity of industrial developments, where all countries travel through the same developmental stages, however evidences from the textile and clothing industry reveal that a multitude of different developmental traits have emerged[277]. A common trait is that countries develop through mastering of single functions and value adding steps e.g. the sewing functions, where competitiveness is related to low labour costs. Increasingly the industries develop regional skills and local provisions emerge, which make the productions increasingly based

[274] Audet, Denis (1996): "Globalisation in the Clothing Industry", in "Globalisation of Industry – Overview and Sector Reports", OECD, pp. 323-355.
[275] Abernathy, Frederick et al. (1999): "A Stitch in Time", Oxford University Press.
[276] Amin, Ash (ed.) (1999): "Post-Fordism: a Reader", Blackwell, Oxford.
[277] Op. cit Audet (1996).

on localised provisions[278]. An important developmental trait is the integration of pre-manufacturing textile-productions, as weaving, spinning, colouring etc. with the manufacturing stages of cutting, sewing, packing etc. The textile industry has increasingly become dependent on the manufacturing industry and vice visa, just as the industrial activities increasingly get interlocked[279]. Consequently, the textile and clothing industry has become treated as a uniform industry e.g. by Abernathy et al. (1999)[280], an approach that is also applied in this chapter.

Similar conditions relate to the Danish industry where producers increasingly have developed competitive strategies towards provision of medium to high quality items at reasonable cost-levels. Productions of high-quality items and high prices support that there can only be on export-market: Western Europe. Productions for the domestic and European markets have been enabled through information sharing programmes with retailers and good analyses of market- and fashion-developments. In addition to good demand-forecasting initiatives are also evident in minimising time requirements in production-cycles, which have been accomplished through applied ICTs and superior logistics[281].

However, increasing labour-costs domestically have somewhat undermined the competitiveness of Danish sewing and other labour-intensive functions. Increasingly the industry has become reliant on international outsourcing, notably in sewing. The upgrading skills and local provisions in established supplying countries e.g. Portugal and Spain, have meant that increasing parts of the production have become outsourced in these regions[282&283]. Quality upgrading has been coupled with rising labour costs and a partial transfer of outsourcing-structures to the Eastern European countries[284]. Patterns of total outsourcing based on Danish designs and foreign provisions are evident for provisions from Asia and Southern Europe. Single process outsourcing gets applied e.g. in Poland and the Baltic countries[285].

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[278] Gereffi, Gary (1999): "International trade and industrial upgrading in the apparel commodity chain", in Journal of International Economics, Vol. 48, pp. 37-70.
[279] Byrne, Chris (2000): "The Industrial and Social Impact of New Technology in the Clothing Industry into the 2000s", available at www.davidrigbyassociates.com/articles, February 2000, pp. 1-21.
[280] Op. cit: Abernathy (1999).
[281] Own research.
[282] Illeris, Sven (1992): "The Herning-Ikast textile industry: an industrial district in West Jutland", in Entrepreneurial & Regional Development, Vol. 4, pp. 73-84.
[283] Kristensen, Peer Hull (1992): "Industrial districts in West Jutland, Denmark", in Frank Pyke & Werner Sengenberger (eds.): "Industrial districts and local economic regeneration", International Institute for Labour Studies, Geneva, pp. 122-173.
[284] Illeris, Sven (1999): "Outsourcing of Textiles and Clothing Industry from Denmark to Baltic Transition Countries", available at www.geo.ut.ee/nbc/papers December 1999, pp. 1-5.
[285] Interview result.

In this chapter it is shown how the Danish textile and clothing industry is subject to the gradual development-processes indicated above. The gradual industrial developments coupled with higher product-qualities have become reflected in different ways e.g. the specialisation of firms within an industrial district, gradual increasing in international outsourcing and reduced domestic employments, and a gradual reduction of export-markets. This chapter explains the current position of the Danish textile and clothing industry. The above conditions have implied that employments have been eroded and domestic production-levels have stagnated. Despite receding European demands, and contrary to most other Western European countries, the Danish industry has managed to increase its exports continuously. The unique performances of the Danish industry is located with a competitive industrial district that supplies most manufacturing services, intensive outsourcing-structures with neighbouring countries and Asia, and good market- and fashion-analyses that together with information sharing enable high responsiveness to demand-changes. Increasingly the Danish industry has become information-intensive where the manufacturing-processes are situated abroad, and design, management, logistics etc. are located domestically[286].

4.2. Industrial Characteristics

Technological innovations have been substantial within this industry and led to development of new modes of production in both textiles and manufacture of clothing. Technological developments have led to different technological trajectories based on various degrees of digitalisation and mechanisation. Subsequent requirements for specialised labour have impacted the production-conditions for the industry in different regions. This section contributes with outlines of some of the important technological innovations and discusses how they impact regional competitive advantages. In Western Europe technologies support specialised production-units based on skilled labour and highly mechanised and automated processes, technological innovations have primarily been targeting speedier production-processes, better qualities and process monitoring. Eastern European and parts of Asian industries instead apply older mechanical equipment in support for large-batch production-lots and economy of scale.

Technological Innovations

Production of textile and clothing has been universal processes based on similar technologies around the world, which make their origin impossible to trace[287]. Innovations in production-technologies have

[286] Interview result.
[287] Harnow, Henrik (1999): "Den tidlige danske textilindustri" (The Early Danish Textile Industry), unpublished working paper.

been modest until the industrial revolution when access to steam power, together with new infrastructures and mechanical precision transformed the conditions for industrial production[288&289]. Since then there has been a wide set of technological innovations located around the world i.e. English innovations in spinning and weaving during the industrial revolution, American and French computerised production-technologies in the post WW II period, and increasingly Asian innovations related to 3D-modelling and automated sewing-processes in the late 1990s.

Most technological improvements have been easy to copy and have got diffused quickly[290] leading to district-wide or even worldwide productivity-gains unless restrict by businesses or national legislations[291]. General trends of the technological innovations within textile and clothing are increased mechanisation and automation of production-steps and a shifting managerial emphasis from functions towards materials flows and production-process[292]. Innovations have led to substitution of labour for capital, need for more skilled labourers, smaller pieces of equipment, and higher product-quality and process-speed. Competitiveness of developed industries not only rests with cost structures associated with substitution of labour with capital, but also with provision of high qualities, speedy delivery, and innovative products that matches the ever-changing demands. A more detailed outline of the technological innovations and industrial forces are presented below[293].

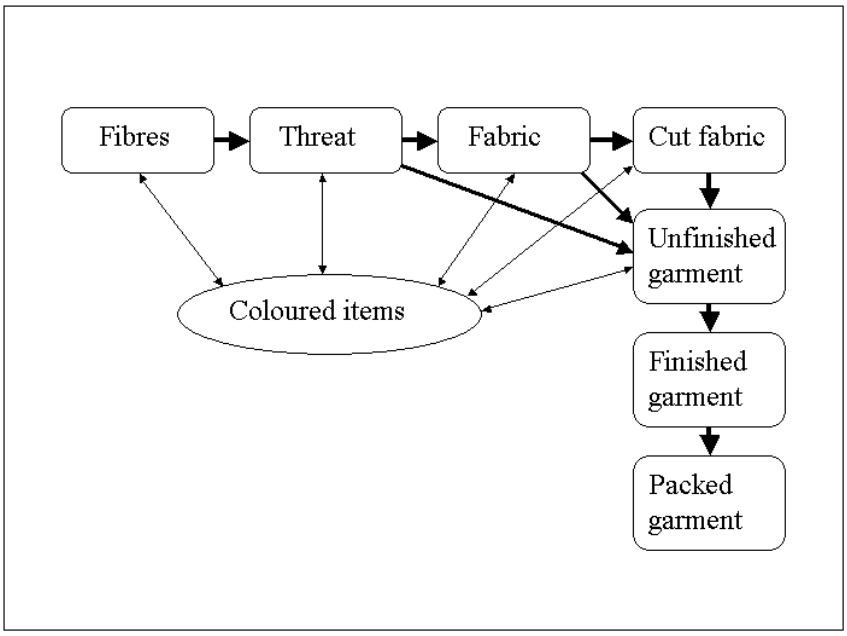
Textiles

Fibres, the raw material for textile production, have undergone some major developments related to inventions of new fibres and new production-processes for known fibres[294]. All the pre-spinning processes of wool and cotton have become increasingly mechanised e.g. rinsing and carting of raw materials. Developments of man-made fibres have revolutionised these conditions: new fibres have been constructed on reuse of existing natural fibres i.e. viscose or based entirely on new materials i.e. synthetic fibres. Synthetic fibres are products from the petro-chemical industry that are produced

[288] Gille, Bertrand (ed.) (1978): ”The History of Techniques”, Vol. 1, “The Industrial Revolution”, Gordon and Breach Science Publishers, London, pp.589-670.
[289] Christensen, Dan (1996): “Det moderne projekt” (The Modern Project), Gyldendal, Copenhagen.
[290] Agerberg, Miki (ed.) (1999): ”De italienska industridistrikten som modell och verklighet” (The Italian District as model and reality), Teldok report No. 128, Stockholm.
[291] Bruland, Kristine (1999) seminar presentation at ETIC, Strasbourg, on the British restrictions on technology transfer under the “Tools Act” and personal diffusion processes.
[292] Hoffman, Kurt & Howard Rush (1988): “Micro-electronics and Clothing”, Praeger, London.
[293] Substantial information on processes and technologies has been accessed from www.just-style.com, www.lectra.com, and www.gerbertechnology.com (1998-2001).
[294] ”Produktionsprocesser og miljøindsats i tekstil- og beklædningsindustrien” (Production processes and environmental efforts in the textile and clothing industry), chap. 3 in ”Renere teknologi i tekstil- og beklædningsindustrien” (Cleaner technologies in the textile and clothing industry) (1999), at Miljøstyrelsen, Danish Environmental Protection Agency, available at www.mst.dk/199910publikat/87-7909-514-3/kap03.htm, November 2000, pp. 1-31.

without any of the known spinning-processes. Whereas the use of cotton has been quite stable through the past decades, use of wool has decreased slightly and man-made fibres have increasing dramatically[295].

Figure 4.1: Material Flows



Spinning-processes have not altered substantially within the past decades. These processes are entirely mechanical and technological innovations have led to improved quality of outputs and increased speed in production. Nevertheless, the mechanical functions are based on the same processes as ever: the teen and the spinning wheel. Probably the most evident improvements of the applied technology relate to multiple spindles, continuous spinning-processes and numeric controls. Due to the increasing importance of man-made fibres the spinning-processes have become partially obsolete, and spinning-processes add ever-smaller values to the industrial value chains.

Similar conditions have been evident for the development of weaving-processes, which are based on mechanical processes all over the world. Substantial improvements have been obtained through continuous weaving-processes. Knitting on the other hand were the latest processes to become mechanised and substantial parts of knitting is still performed manually e.g. in Asia[296]. The latest technological developments have targeted faster production and better qualities, which have been obtained through digitisation and automation. Applications of computer-based technologies enable more advanced patterns and product improvements as seamless knitting for socks. Latest technological

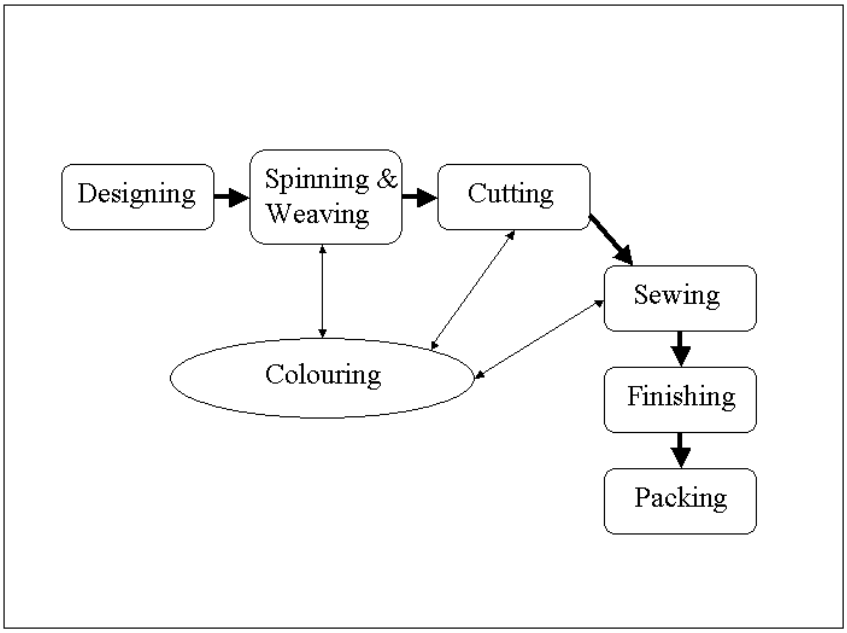
[295] "Competitiveness of the EU Fabrics Industry" (1994), in Textile Outlook International, No. 54, pp. 90-107.
[296] Interview result.

innovations in both knotting and cutting have been related to provision of better quality products, faster processes, and the digitisation also enable new pattern-processes and improved process-management. A substantial gain from digitisation of knitting and weaving is related to the process-management, where resource-flows can be supervised and output monitored. Automation of these processes also enable process-reports that codifies product qualities, errors etc.[297].

More substantial improvements have been evident in the "wet-treatment" of materials i.e. chemical processes of washing, colouring, printing and the like[298]. Innovations have transformed labour- and time-intensive processes into highly automated and chemical steps. Wet-treatments suit several purposes of preparing materials for colouring, belabour surfaces and make control of fabrics. Preparation steps include warmth-treatment, rinsing and chemical processes that improve the preceding colourings. Chemical processes are also applied for invention of new materials and development of new surface-structures that give new impressions and perceptions of the fabric. And importantly, wet-processes get applied to control products for correct shrinking, and for wash and colour resistance[299]. Technological improvements have transformed the time-consumption in these processes, reduced their costs and changed its position in production-processes, e.g. improvements in shrinkage testing have reduced testing-times from typically 8 hours to approximately 15 minutes[300]. These forms of testing can now be performed more frequently and "on the move" without stopping productions. Process-innovations also relate to improved colouring that can be performed at lower temperatures with lesser damage to the fabric, which hence allows for testing after the cloth has been sewn.

[297] Op. Cit: Hoffman & Rush (1988) & op cit. Abernathy et al (1999).
[298] Op cit: "Produktionsprocesser og miljøindsats i tekstil- og beklædningsindustrien" (1999).
[299] www.just-style.com (2000).
[300] www.raitech.com (2001).

Figure 4.2: Value Adding Steps



Colouring-.plants form substantial parts of industrial structures of these wet-processes. Developments of large mills and production-plants enable that all the processes get performed at a single location, which generate economy of scale and lower intermediate transportation-costs. Two strings of colouring technologies have developed. One string of the process-technology operates by fixing the materials to the same piece of equipment and through which the fabric get exposed to different liquids and colours. This technology enables production of both large batches and very small batches down to 15 kilos. In the other technological approach continuous colouring-processes are enabled as materials run through separated machinery that performs the different steps. Dyeing-processes in colouring-plants are based on colouring by single colours at high qualities. Printing-processes instead allow for application of numerous colours and in varying patterns. Printing can either be full printing of the weaved/knitted fabrics or a limited printing of parts of clothing. Latest technological improvements relate to process-improvements that enable quicker processes of better qualities and at higher precision with the use of lesser chemicals and water. Some plants have accomplished savings of water up to 50 percent, and reactivity of colour chemicals have improved from 60-70 percent to 75-80 percent[301]. Environmental concerns and healthy products play increasing roles in the international competitive structures.

[301] Op cit.: ”Produktionsprocesser og miljøindsats i tekstil- og beklædningsindustrien” (1999).

Clothing

Manufacture of clothing has also undergone some evident technological improvements. Innovations relate to digitisation of pre-sewing processes and mechanisation of cutting and sewing. Despite much research and efforts put into lean sewing and fully automated manufacturing-processes, an entirely automated production-process has not yet been accomplished: sewing remains largely dependent on human skills and operations[302].

Digitisation and introductions of computers have assisted the design-processes substantially. Design-processes have traditionally been based on trial-and-error processes in prototyping where a physical prototype has been constructed on a dummy or a human model to reach the wanted fitness. Subsequently the prototype has been used for generating cutting- and sewing-patterns. Measurement for particular pieces of clothing has been subject to the figures of selected models and dummies. Digitisation of design-steps and virtualisation of models have transformed production-processes, physical prototypes are no longer required, and patterns are generated automatically. Technological improvements are related to improved performances of computers, increased multimedia applicability, 3D virtual modelling, networking etc. but also to automated pattern making and computer integrated manufacturing. In addition, inputs from personalised measurements enhance the individual fitness of clothing and leads to more appropriate measures and sizes.

Cutting of cloth into special pieces for sewing has become fully automated. Automation of this process has been accomplished via digitised information-processes of design-processes, which can generate automatic cutting-patterns. Automation-processes also include automated fabric handling and marker making, which is the transformation of individual cutting-patterns onto the woven fabric. Fittings of patterns in order to reduce the materials-waste are often complex, time-demanding processes that require highly skilled labour. Computerisation of this step has offered much speedier processes and reduced materials-waste up to several percent[303]. From the 1980s onwards these functions have increasingly become automated within Danish industry, which have led to substitution of manual labour with machinery.

By-and-large the sewing-processes have remained labour-intensive production-steps, subject to only minor improvements in the technologies since invention of the sewing machine. The limited mechanisation in this manufacturing step has been obtained through two strings of process-

[302] Abernathy, Frederick et al. (1999): ”A Stitch in Time”, Oxford University Press.
[303] www.gerbertechnology.com (2000).

improvements of machinery; the first is the familiar lockstitch machine where the cloth is moved over a fixed plate and sewn through application of thread spooled upon a bobbin, and the second is an industrial chain-stitch machine with moveable heads that do not depend on spools or bobbins[304]. Assembling of 2D-materials into 3D-products has been fully automated in other industries as the automobile industry where computers and robots handle the assembly of rigid components. Sewing of clothing and the manufacture of 3D-garments have so far not been successfully automated as the flexible materials and varying elasticity pose substantial obstacles to automated sewing-processes. Automation in assembling has nevertheless been partially accomplished for some relative simplistic operations where materials and designs have been pre-programmed into 2D-operations e.g. welding or sewing of zippers[305]. Sewing-processes constantly depend on human skills in moving materials, for correct seaming and in continuous adjustments. Research into full automation of these processes has only granted little success due to the technological difficulties with mechanical sensing of materials and continuous adoption to changing materials, patterns and designs[306]. Technological innovations relate to faster sewing equipment and materials development that evades the melting and ruining of materials subject to the high temperatures associated with fast sewing.

Post-sewing functions including production-control, steaming, packing etc. have been subjected to varying degrees of technological improvements. Substantial parts of production-control are manual activities, but through increasing application of digitised processes automated error-reports can be generated in textile-production and shrinkage-testing systems enable control of fabrics and adjustment for correct features. Through network-functionalities of DMM-technologies such as video-conferencing and image-transmissions, the control-function may become distributed. Ironing, steaming and packing have become somewhat mechanised but largely depend on manual feeding. Despite possibility of a functional separation of these steps, manufacturers prefer integrated solutions that offer all the post-sewing functions in combination[307].

Manufacture of carpets has also undergone substantial technology- and process-changes. Traditional knitted fabrication of carpets has increasingly become replaced by machinery in knitting and by new production-processes of tufting. Tufting-processes are based on injection of small pieces of yarn or synthetic fibres into a prepared woven sheet. Advantages of tufting-processes relate to higher degrees

[304] Op cit: Abernathy et al. (1999).
[305] Interview result.
[306] www.just-style.com (2000).
[307] "Structural Development of the T/A Industry in Carpi District", (1997), Working paper, Citer, Emilia Romagna Textile Information Centre, Carpi, Italy, pp. 1-79.

of mechanisation and possibilities to manufacture carpets of grey materials and invoke colouring- or printing-processes later. These technological advances enable a restructuring of production-processes where materials do not have to be coloured until the final stages of production. Digitisation and computerisation have also offered substantial production-gains in this step too: computers handle the colouring- and printing-processes and get applied in process-management. Innovation of technologies relate to speedier processes and increased automation[308].

Technological innovations have been evident to the logistics function too. Transportations have undergone general improvements during past decades, which also have benefited the textile and clothing industry, indeed the present outsourcing models and distributed structures can not have emerged without well-established transportation networks. Air-shipments are speedy but expensive and only applied at limited scale. Seaway shipments are on the other hand very slow and inexpensive, and applied extensively for transportation over long distances where provisions are not sensitive to weeks of transportation. Rail- and road transportation are used extensively within Europe, the faster the shipment the more likely it is to be the relatively expensive road-distribution. Computerisation provides major technological improvements leading to speedier and cheaper transportation, and better services[309]. EDI-messages (standardised codified electronic messages in production, distribution etc.) offer means for integration of transportation services, track-and-trace for processing information and GPS (General Positioning System) for satellite-location of shipment. Standardisation initiatives are evident in generating EDITEX (EDI for the Textile industry[310]), EDI-messages for finances, transports and textile industry[311]. Technological innovations have related to digitisation of transportation services for seamless and uniform incorporation of transportations, and for universal standards for the physical transportation e.g. same structure of containers for hanging clothes. Warehousing has also been substantially aided by digitisation, and has increasingly become integrated with transportation and logistic services.

Regional Developments

Productions of textiles and manufactures of clothing are essential processes to any developing economy, but tend to loose its relative share of economic activity as the economies mature. Traditionally markets have been highly differentiated and separated by substantial transportation costs

[308] Interview result, Citer (1999).
[309] Benjamin, P et al (1999): "Information Technology Infrastructure for Textile and Apparelindustry in Hong Kong", Electronic Markets, Vol. 7, pp. 9-12.
[310] www.aster.it (1999).
[311] "Best Practice for Information Technology in the Textile Industry" (1999), ESPRIT Project, available at www.atc.gr/bit February 2000, pp. 1-28.

and other trade barriers, hence regional industrial developments have primarily been subjected to regional market structures. Despite geographical segregation of markets some international features have impacted regional developments and transcended worldwide industrial developments. Access to cheap resources and good markets, and protection against foreign competition has guided much international trade policy. Historically the access has been obtained from colonies that have provided both cheap labour and cotton. Less militaristic measures are applied today in the GATT-agreement ensuring levels of free trade. Protection from foreign competition has been another important policy, pursued in developed and developing economies alike[312&313]. Presently, trade barriers have been institutionalised in the Multi Fibre Agreement (MFA) that restricts the trade of some crucial textiles.

Regional development of the textile and clothing industry has been subject to a wide set of forces including the technological innovations, regional labour markets, national trade policies etc. As the national industries have matured they have developed unique trajectories of competencies and competitiveness[314]. Industries may be unsuccessful in maintaining competitive advantages and hence regional structures will wither away e.g. most of British textiles and clothing, where previous technological advances have been adopted by other countries with lower labour costs[315]. Economic performances and societal developments relate to historic developments, capital accumulations, composition of labour markets, applications of technologies, infrastructures etc. These structures have developed through time leading to different national structures and performances, some of which are outlined below.

International Traits

Different approaches have been pursued in explaining regional economic developmental traits. At the aggregate level it has been possible to identify national characteristics that shape the regional[316] and national industrial processes, and which condition the international trade[317]. Some of the factors determining international trade are accesses to natural resources, factor-costs, and technological

[312] "Danske virksomheder og WTO 2000" (2000) (Danish Businesses and the WTO 2000), available at www.efs.dk/publikationer/rapporter, November 2000, pp. 1-13.
[313] Different political measures have included Swedish legislations on obligatory use of national garments and exclusive Danish deals for supply of cloth for the navy. See op cit. Harnow (1999) and Christensen (1996) for further outline of these policies in Northern Europe.
[314] Op cit: Audet (1996).
[315] Op cit: Bruland (1999).
[316] Zysman, John et al (1996): "Tales From the 'Global' Economy: Cross National Production Networks and the Re-organisation of the European Economy", in BRIE Working paper, No. 83, pp. 1-39.
[317] "Globaliseringens årsager og konsekvenser" (1999) (The Causes and Consequences from Globalisation), HTS Kartellet, available at www.hts.dk/pjecer, January 2000, pp. 1-74.

abilities. Less aggregate are the analyses of regional management-conditions[318], regional learning[319], and local network-structures[320].

From a management perspective there exist some specific regional structures that determine the mode of production-management and societal organisation; regions show high specificity in composition of competitive environment, educational systems and management-strategies. Three managerial regimes have developed rooted in the English proprietary firm, the American managerial enterprise and the Japanese collective structures[321]. European firms are characterised by both the early English firm structures of tight family-based integration of ownership and management, and the later American managerial school with separation of management and control. The English structures have been developed under the industrialisation and early mass-producing structures, where the capital owners possessed scientific know-how and management control. The American managerial system seems more geared for the scientific revolution and multi-plant operations through tighter links between managerial functions and specialist employees. Both structures are based on firms being separated entities acting on impersonal markets, which are opposed by the Japanese models of networking between clusters of firms.

Managerial schools may indicate how organisations operate and interacts, but does little to explain the economic development of regions. Historic events and policies have structured the conditions for national developments, and explain the present performances of different regions[322]. In the case of developed countries, periods of capital accumulation and societal developments have provided the imperatives for technological innovations, for skilled labour and for industrial developments. Firms in these economies generate competitive advantages primarily through application of intensive capital investments in advanced technologies and through well-educated but expensive labourers. These characteristics mark most of Western European textile and clothing industry, which consequently competes on specialised products of high quality and at high prices. Developing countries on the other hand lack both capital and skilled labour-force, and instead compete in low-technology fields and gain

[318] Lazonick, William (1992): "Business Organisation and Competitive Advantage: Capitalist Transformation in the Twentieth Century", in Giovanni Dosi et al. (eds.): "Technology and enterprise in a Historical Perspective", Clarendon Press, London, pp. 119-163.
[319] Lundvall, Bengt-Åke (ed.) (1995): "National Systems of Innovation – Towards a Theory of Innovation and Interactive Learning", Pinter, London, introduction, pp. 1-19.
[320] Piore, Michael & Charles Sabel (1984): "The Second Industrial Divide", BasicBooks, USA.
[321] Op cit: Lazonick (1992).
[322] Audet, Denis (1996): "Globalisation in the Clothing Industry", in "Globalisation of Industry – Overview and Sector Reports", OECD, pp. 323-355.

competitiveness from low labour-costs, which is the case for most Mediterranean rim-countries, Africa and parts of Asia.

Former planned economies of Eastern Europe and the former Soviet Union are marked by high degrees of industrial specialisation and mechanisation, where specific areas have been selected to provide the planned production for the entire region[323]. The Baltic countries and Poland have been such areas where textiles have been produced and clothing manufactured. Today these countries possess relatively high degrees of capital and production-mechanisation, and a large pool of trained labourers at low costs. Competitive advantages relate to large-batch production-processes at large plants through application of shift-labour, but increasingly they will compete on provision of quality products[324].

National Traits

Even though the above general managerial and economic developmental trends have enabled identification of common traits for these three regions, evident differences exist between the individual nations within these regions. Western European countries display a wide array of different competitive structures and strategies rooted in their historical conditions[325]. The British textile and clothing industry used to do well due to early technological developments, but their competitive advantages have not been sustained. Another factor of the British industrial decline has been the diminishing importance of wool in production of textiles. Large-scale production-plants are viable organisational structures for some production-processes e.g. in Germany, in production of synthetic fibres and chemical processes of colouring etc. Large-scale production is also viable in manufacture of clothing depending on access to low-cost labour, which are available in countries of Portugal, Turkey, and Eastern European countries like Poland, Rumania and the Baltic countries[326]. Other forms of competitive advantages are found in countries like France and Italy, who have developed high-skilled fashion designers and provide small batches of high quality products. In countries like Italy and Denmark the small-batch production-structures have led to industrial specialisation and network-structures within districts.

Differences between countries are also evident within the Asian region where Japan has been the regional manufacturing plant dependent on outsourcing labour-intensive functions to low-cost

[323] Interview result.
[324] Op cit: "Globaliseringens årsager og konsekvenser" (1999).
[325] Op cit: "Competitiveness of the EU Fabrics Industry", (1994).
[326] Mygind, Niels (1998): "The Internationalisation of the Baltic Economies", BRIE Working Paper, No. 130, pp. 1-32.

countries in South-Eastern Asia[327]. Japan was the early-industrialised country of the region, and followed by Taiwan, Korea and Hong Kong, who gained competitive advantages from low wages and coping of technology[328]. With the industrialisation of these countries, their factor costs have altered and depend now on outsourcing of labour-intensive functions to neighbouring countries in Southeast Asia. Cross-national division of labour and regional outsourcing get structured through the organisations of multinational corporations. China has due to its tremendous domestic market and protectionism been sheltered from these international structures and developed their own industry, which has only recently been subjected to international trade[329].

Textile and clothing industry has not only grown, but also diminished in some regions notably in some developed countries like the UK, where textile and clothing has been doomed as a sunset industry[330]. Nevertheless, this industry has in UK and other parts of Western Europe shown its longevity through restructuring and international outsourcing based on improved logistics, enhanced communication tools, changed production-cycles and computer integrated manufacture. Industrial development is also evident in other countries and regions.

> "In many developing countries the development of clothing manufacture has been followed by fabric production. This 'upward integration' is a classical form of industrialisation in which developing countries start to master the most labour intensive stage of production, the making-up of garments, and then develop fabric and yarn sectors to supply it with materials." (Scheffer, 1994[331]).

Similar developmental trends relate to the regional upgrading of value-formation and to altered distributions of powers between producers and buyers[332&333]. In buyer-driven value chains the buyers are instrumental to the international outsourcing, and industrial subcontracting is subject to intensive competition where low production-costs are amongst the primary strategies. Producer-driven chains are instead governed by the producers and associated with branding and quality of products. Whereas buyer-driven chains are found within textiles, producer-driven chains are evident in large parts of clothing. Rents from producing in producer-driven value chains based on branded names and quality

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[327] Gereffi, Gary (1999): "International trade and industrial upgrading in the apparel commodity chain", in Journal of International Economics, Vol. 48, pp. 37-70.
[328] Op cit: Lazonick (1992).
[329] Op cit: Gereffi (1999).
[330] Byrne, Chris (2000): "The Industrial and Social Impact of New Technology in the Clothing Industry into the 2000s", available at www.davidrigbyassociates.com/articles, February 2000, pp. 1-21.
[331] Scheffer, Michael (1994): "Internationalisation of Production by EC Textile and Clothing Manufactures", in Textile Outlook International, No. 51, pp. 101-123.
[332] Op cit.: Gereffi (1999).
[333] Campbell, Alexandrs (1998): "Cooperation in international value chains: comparing and exporter's supplier versus customer relationships", in Journal of Business & Industrial Marketing, Vol. 13, pp. 22-39.

products are evidently larger than the buyer-driven structures, which makes it preferable to most businesses to develop their qualities, brand their products, and advance into producer-driven chains.

Industrial maturations and developments of skills and qualities can only be obtained through corresponding developments of markets. Markets for textile and clothing have been highly segregated until the 1950s. Since then there has been made progress towards internationalisation of trade[334]. Generally, markets have become much more internationalised due to changed politics, rising income-levels, globalisation of information and trends, improved transportation-possibilities and international structures of value chains. Despite internationalisation of industry the local markets are still important to regional industrial developments, hence the Western European trends towards upgrading of productions, higher qualities and consequently higher prices have been tightly related to altered composition of European demands[335]. During the last half-century the income levels have increased dramatically in Western Europe and led to altered demands for textiles and especially for clothing[336]. In the 1970s and early 1980s demands were based on undifferentiated standardised products e.g. the Parker coat, which were provided through mass-produced and large-scale structures. Competitive advantages were located with economy of scale in production and integration of value chains providing low-cost items. Development trends of the 1980s included affordable fashion garments and segmentation of markets supplied with increasingly differentiated items. Industrial structures included horizontal integrations, targeted outlets, digitalisation of information streams, applications of CAD/CAM-technologies, and international outsourcing. In the 1990s the trends towards individualisation of tastes and specialised provisions have developed further, and industrial structures have increasingly developed towards tighter relationships and interconnected retail. The competitive situations have been influenced by international competition, risk reductions and lowering of stocks, obtained through EDI-messaging, small-batch productions and supply chain management.

District Traits

Evident differences have developed between some local economies and between national industries. Probably the most famous industrial districts are found in Northern Italy where special local conditions have inspired the development of unique industrial structures based on numerous small and

[334] www.davidrigbyassociates.com/articles (2000).
[335] www.just.style.com (2001).
[336] Rigby, David (1992): "Textile Supply Chain Management: New Problems, New Solutions", available at www.davidrigbyassociates.com/articles, February 2000, pp. 1-9.

medium sized enterprises that in unison perform all value adding steps of an industry[337&338]. Unique accesses to resources such as cheap or good raw materials, skilled labourers, developed infrastructures, or to special access to markets impact the formation of such local clusters[339]. The special access to production-facilities makes it especially attractive for firms within a given industry to be located in these locations and eventually clusters with many specialised firms will emerge. Competition amongst the local firms is intense within clusters, which compels businesses to seek continuous innovations and productivity gains in order to survive. Sustained competitive advantages stem from the fears competition, exceptional levels of local innovative activity and associated lower costs of productions. Hence, clusters may maintain their competitive advantages through continuous innovation-processes even though the advantages from original conditions fade away.

Provisions of special inputs in production or unique accesses to markets are not sufficient to determine the future development of local industrial organisation. On one hand it is possible that intensive local competitive pressures lead to terminations of more business than births, which will lead to industrial concentration[340]. Alternatively, if the birth rate of firms is sufficiently high there will develop increasing numbers of firms and rising levels of competition. Determinations of developmental traits for local economies have been impacted by the composition of technological innovations and managerial policies. Technological developments are under specific circumstances crucial to the future direction of both individual firms and local industry. In situations of industrial divides the individual decision-maker is faced with choices of production-technologies that impacts the entire industrial structures and developments of districts[341]. The decisions taken by one firm will impact other decision-makers within local industry through its impacts on local labour markets and industrial production-processes. Post-WW II innovations in production-technologies have offered businesses-opportunities either to apply high degrees of mechanisation for mass-production or to apply specialised machinery for small-batch productions. The Fordist modes of mass-production and subsequent deskilling of labour have been a preferred developmental trait by many local industries. Some clusters in the Third

[337] Balestri, Andrea (1982): "Industrial Organisation in the Manufacture of Fashion goods: The Textile District if Prato", available at www.comp.lancs.ac.uk, December 1999.
[338] Best, Michael (1996): "The New Competition: Institutions of Industrial Restructuring", Polity Press, London, introduction, pp. 1-26.
[339] Porter, Michael (1998): "Clusters and the New Economy of Competition", in Harvard Business Review, Vol. 76, pp. 77-91.
[340] Staber, Udo (1998): "Inter-firm co-operation and competition in industrial districts", in Organization Studies, Vol. 19, pp. 701-724.
[341] Op cit: Piore & Sabel (1984).

Italy have instead applied specialised technologies, crafts-based employment relations and generated competitive advantages through industrial flexibility[342,343&344].

Social and personalised structures that bypass these economic and technological explanations have been identified[345&346]. Granted, the Italian industrial districts are somewhat based on unique local resources and industrial structures e.g. well-developed labour markets, social involvements and infrastructures, but the success of the industrial districts has been associated with unique competitive and cooperative relations between individual firms[347&348]. Firms within a given district have chosen to specialised their activities and only perform a single or very few value adding functions. The firms of the district become very dependent on receiving orders from their neighbouring firms, which are reasoned through personalised ties and industrial specialisation. Competition is fears between businesses at specific levels of the value chain, but cooperation is also evident amongst these firms and amongst the members of value chains. District-based value chains are generally volatile, where a successful firm becomes the owner of production-organisation in one season, but possibly the loser in the coming season. In order to survive these competitive structures the firms keep down overheads through specialisation and produce through outsourcing of tasks. A key element of the network-structures is the high degrees of labour mobility, entrepreneurial activities, and personalised or family ties found within these districts. The labour force is highly skilled and well trained, which makes it easy for any firm to employ extra staff during peak seasons or successful spells. Labour-mobility further ensures information diffusion and shared knowledge-formation amongst the district firms, and a continuous renewal of personal networks.

Besides the networked structures there exists a wide set of local institutional arrangements that have institutionalised knowledge sharing and diffusion of information. These structures are adjusted to regional industrial patterns and skills, and perform different functions depending on local needs. Functions of these regional information centres relate to knowledge-creation and sharing within

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[342] Op cit: Agerberg (1999).
[343] Antonelli, Cristiano (ed.) (1988): "New Information Technology and Industrial Change: The Italian Case", Kluwer Academic Press, London, chapters 1 & 2, pp. 1-32.
[344] Bartezzaghi, Emilio et al (1997): "Strategically flexible production and the extra-firm infrastructures: how regions become attractive", in Integrated Manufacturing Systems, Vol. 8, pp. 333-346.
[345] Granovetter, Mark (1985): "Economic Action and Social Structure: The Problem of Embeddedness", in American Journal of Sociology, Vol. 91, pp. 481-510.
[346] Kumar, Kuldeep et al (1998): "The Merchant of Prato Revisited: toward a third rationality of information systems", in Management Information Systems Quarterly, Vol. 22, pp. 199-226.
[347] Sengenberger, Werner & Frank Pyke (1992): "Industrial districts and local economic regeneration: Research and policy issues", in Frank Pyke & Werner Sengenberger (eds.): "Industrial districts and local economic regeneration", International Institute of Labour Studies, Geneva, pp. 3-29.
[348] Sabel, Charles & Jonathan Zeitlin (1997): "World of Possibilities", Cambridge University Press.

different fields as production-technologies, ICTs, training programmes, fashion- and market-analyses, brokerage functions and the like. Generally the centres provide special information that the individual small and medium sized businesses do not hold resources to access otherwise, this includes information about foreign conditions, assistance with exports and the like. CITER (Centro Informazione Tessile dell'Emilia Romagna) is on such information-centre for the textile and apparel industry in Carpi district, Italy that arranges events for information sharing and training-programmes[349]. The Carpi district is like many other Italian districts characterised by many small producers without much managerial skills or knowledge about ICTs[350]: a prime target for the CITER-centre has been to enhance information-levels about management and possibilities from ICTs, just as it is involved with other Italian institutions to develop new ICT services that suits the needs of the textile district. This work includes identification of local needs and development of web-based EDI-messages, and shared pattern-databases[351&352]. Similar institutions are found in Danish textile and clothing district in the Herning-Ikast region[353&354]. Danish industry is generally better suited to apply EDI and other ICTs but still needs assistance in exporting, international marketing, environmental regulation, and access to information on latest standards and regulations[355].

Summary

Technological innovations have been substantial for the industry. Innovations relate to mechanisation and automation of textile production, and to computer-aided design and manufacture. In the manufacturing-processes there have been substantial innovations in pre-sewing functions but only little advances in the actual assembling of materials. In addition to the innovations that have improved productivity, technological developments have shifted barriers to minimum lot-sizes and the order of production-steps, where colouring has been postponed to later stages. In addition innovations in production-technologies, there have been substantial improvements associated with production-managements and logistic. Information has increasingly become separated from the physical production-steps and provided through new means: fashion and market analyses, separation of design

[349] Information about CITER and its services has been acquired through numerous interviews at CITER, November 1999.
[350] Op cit: "Structural Development of the T/A Industry in Carpi District", (1997).
[351] "The Tex.AT.Work Project" (1999), Aster, Bologna, Italy, pp. 1-26.
[352] "Textiles and Telematics, The Future", (1999), Final report, Aster, Bologna, Italy, pp. 1-39.
[353] Illeris, Sven (1992): "The Herning-Ikast textile industry: an industrial district in West Jutland", in Entrepreneurial & Regional Development, Vol. 4, pp. 73-84.
[354] Maskell, Peter & Anders Malmberg (1995): "Localised Learning and Industrial Competitiveness", BRIE Working paper, No. 80, pp. 1-29.
[355] Information is based on interviews with employees at both Federation of Danish Textile & Clothing, and Industry Council for Herning-Ikast-Brande, (2000).

and virtualisation of models, sourcing of computer capacity for marker making, sourcing of logistic services, financial services, sourcing of sales, distributed control etc.

In addition, increasing levels of internationalisation and development of regions with unique competitive advantages have marked the industry. Regional, national and district-wide competitive advantages stem from accesses to natural resources, factor costs, applied technology and availability of skilled labour. Though the advantages are rooted in theses stocks the competitiveness show evident developing traits. Relative early-industrialised economies have lost their competitiveness, whereas other economies have managed to sustain theirs. Sustainability is related to upgrading of processes and value chains, combined with outsourcing of some functions to low-cost regions. Upgrading of value chains have shown different developmental traits: national protection and gradual development in China, coping of techniques and upgrading of labour skills e.g. in Portugal, Spain, Taiwan and Korea, and district-wide upgrading of skills and local cooperation in Prato, Carpi and Herning-Ikast. Eastern Europe now stands with the possibilities for speedy developmental traits, combining low wages and technological learning and advances obtained through international value chain structures.

4.3. International Trade

Trade has increasingly become internationalised through the past decades. Indeed global trade has grown at rates 50 percent higher than global production[356]. Globalisation of trade and national patterns of trade are the topics for this section. Trade evidences indicate declining performances of West-European industry and by increasing performances by the Asian. However, there are large differences between the individual countries, and Danish industry does comparatively well when it comes to trade-performances.

It has been a well-established fact for centuries that different businesses and industries hold different competitive advantages related to the division of labour and application of technology in production[357]. In the realm of classical economic theory it has been argued that countries experience some economic and societal development-patterns[358] and that trade between countries reflect their different position in the economic developments, which result in national comparative advantages[359].

[356] www.wto.org (2001).
[357] Smith, Adam (1776): "The Wealth of Nations", Penguin Books, London, 1986.
[358] Karl Marx theories outlined in Hector Estrup (1991): "Nogle grundtræk af den økonomiske teoris udvikling" (Some Development Traits of Economic Theory), Jurist- og Økonomforbundets Forlag, Copenhagen.
[359] Ricardo, David (1815): "Essay on Profits", extracts in Mogens Boserup (ed.) (1979): "Deres egne ord" (Their Own Words), Akademisk Forlag, Copenhagen.

Through processes of capital accumulation a given economy will be able to upgrade and employ increasing levels of capital or technology in production, but increasing capitalisation of production leads to diminishing returns on capital investments. International trade is hence based on technology gaps, but through processes of capital accumulation and price adjustments factor productivity in different countries will eventually converge. These early contributions have provided powerful insight and explanatory powers in analysing trade between nations that have developed differently e.g. the composition of trade between developed and developing regions. However, development of international trade increasingly reveals that trade within homogeneous regions has grown much faster than between heterogeneous regions. These trade developments have not been captured sufficiently by the classical trade theory.

Later trade-theories instead focused on the factors behind national competitiveness, what is moveable and what is not. It is suggested that capital is a highly mobile factor and that internationalisation of trade will enable that capital moves freely and become employed where the returns are the largest[360]. This approach explains trade related to technology gaps, but considerations must also be given to the increasing volumes of trade between countries with equal factor compositions, which calls for analysis of particular industries[361]. Despite equal conditions, different national industries develop differently based on the application of technology, product differentiations etc[362].

Economic theory provides ample arguments for the benefits from international trade based on a better international deployment of resources and worldview productivity gains i.e. location of specific industries in countries that are specially endowed or have become specially skilful and productive. Consequences from the internationalisation of trade are that national industries get exposed to competition, which may lead to exposure of relative incompetence and insufficient levels of productivity. Trade will hence lead to imports of cheaper or better products from abroad and a local industrial restructuring or in worst-case industrial termination. Politics play important roles as well: political considerations deal with the economic and societal consequences from industrial restructuring, temporary unemployment and reduced incomes. Such considerations have led both developed and developing countries to impose trade barriers to provide partial protection that enable the economy to adjust more gradually; developed countries to avoid the industrial restructuring and

[360] Fagerberg, Jan et al (eds.): "Technology and International Trade", Edward Elgar, Cheltenham, UK, Preface.
[361] Porter, Michael (1990): "The Competitive Advantages of Nations", Free Press, New York.
[362] Wolff, Edward (1997): "Productivity growth and shifting comparative advantages at the industry level", in Jan Fagerberg et al (eds.): "Technology and International Trade", Edward Elgar, Cheltenham, UK, pp. 1-19.

temporary unemployment due to cheap imports, and developing countries to protect their enfant industries from competition from established industries of developed countries.

In face of the widespread national interests of protecting home markets from international competition and wishes to gain access on foreign markets, WTO has been established to promote free international trade. WTO who has been influential in reaching the free trade agreements institutionalised in the GATT treaties. GATT agreements do not constitute any end to trade barriers but work towards gradual reductions of tariffs and quotas, just as they deal with the non-tariff restrictions on trade: estimated to 2-10 percent of total exporting costs[363]. GATT recommendations have for the trade in textiles and clothing been included in a Multi-Fibre Agreement (MFA) that was agreed upon in 1973, but has been gradually modified since. In its present form the MFA puts quantitative limits to international trade on cotton-based yarns and some pieces of final garments. Agreements state that restrictions shall gradually diminish, reduced by approximately 50 percent by 2002, and terminate by year 2005[364]. These agreements have only been enabled through delicate negotiations between the major trading blocks of Europe, America, Asia and developing countries. Unfortunately China has not taken part in negotiations nor accepted the conditions prior to 2000, which is a major shortcoming of these structures.

The MFA includes more than tariffs and related trade barriers as it also encompasses coping of clothes, origination declarations, re-direction of trade, duping of products etc.[365] Coping of clothes is a major problem as firms easily can monitor the designs by others and copy them without own investments in designs. Innovative entrepreneurs may also attempt to bypass the established quota system and apply incorrect declarations on origin and re-direct trade, the MFA suggests measures for standardising international declarations e.g. setting up measures for determining the contributions from international belabouring of materials. Duping of products on international markets has also been applied to boost the national industry, which has been restricted by agreement.

Trade Evidences

Internationalisation of textile and clothing industry has been evident within the past decades. Trade-patterns have shifted; most international trade remains located as intra-European trade, and

[363] "Danske virksomheder og WTO 2000" (2000) (Danish Businesses and the WTO 2000), available at www.efs.dk/publikationer/rapporter, November 2000, pp. 1-13.
[364] Khanna, Sri Ram (1994): "The New Gatt Agreement: Implications for the World's Textile and Clothing Industries", in Textile Outlook International, No. 52, pp. 10-37.
[365] www.gatt.org

increasingly Asia has become a major player for producing and exporting textiles. Evidences indicate that Europe production-conditions have been crippled by rising wages, increasingly got dependent on textile imports from other regions, and consequently that sewing of clothing get performed in neighbouring regions[366]. Asia is the region in the world with the largest trade surplus, and Africa and Eastern Europe have emerged as major supplier to Western Europe, and Latin America as supplier to North America. The increasing importance of developing countries and the former planed economies suggests that industry has become truly global. Internationalisation of industry is primarily reflected in increased trade levels but also moderately in foreign direct investments, which reflect the above trends in trade. Foreign direct investments are however quite limited due to generally small sizes of companies in this industry[367].

International trade in textiles and clothing has increased through the past decades and in 1999 the total value of international trade in textiles reached 148 billion $ or 2,7 percent of world total trade in merchandise. Corresponding figures for clothing are 186 billion $ and 3,4 percent[368]. Developments of international trade through the past quarter-century suggest that textiles still add substantially to world economy, but that the relative importance has been diminishing e.g. nations have become increasingly self-supplying and textiles add relatively less to industrial value added. On the other hand clothing has gained substantially in the value-added, which is related to increasing internationalisation of production and higher product differentiations. Clothing has despite regional slow-downs in Asia 1998 and Europe 1999 shown constant positive growth rates partly due to increasing trade between Latin and North America.

Table 4.1: World clothing and textile exports

%-share of world total export in merchandise, 1975-1999.

	1975	1985	1991	1999
Textiles	3,1	2,9	3,3	2,7
Clothing	1,9	2,5	3,4	3,4

Source: Audet, 1994[369] & www.wto.org, 2001.

Generally, the trade-patterns show that internationalisation of trade mostly remain a question of intra-European trade where the different EU-countries export to each other. But, there also exist intra-Asian

[366] "Competitiveness of EU Fabrics Industry" (1994), Institut Francais de la Mode, in Textile Outlook International, No. 54, pp. 90-107.
[367] Op cit: "Globaliseringens årsager og konsekvenser" (1999).
[368] www.wto.org (2001).
[369] Op cit: Audet (1996).

trade boosted by the success of China, which is the world's largest producer, and by Hong Kong, which redirects most of Asian production[370]. The quite limited intra-American trade is related to North American outsourcing of clothing manufacture to Mexico.

Textiles

After some turbulent years of minor reductions in world trade in the early 1980s followed by impressive growth rates at 15 percent in the second half of the 1980s, world trade in textiles in the 1990s have settled at a more steady rate i.e. annual growth-rates were 4 percent through the decade. Substantial parts of world trade in textiles have been performed as intra-European trade (42,8 billion $), which constituted nearly 30 percent of world trade in textiles in 1999. However, the level the intra-European trade has diminished substantially compared to global textile trade since 1990 where it amounted to more than two fifths of world trade. 1999 were especially bad for intra-European trade with an overall decrease at 7 percent. The reduction in intra-European trade is also reflected in the exporting position of Western Europe where the shares of world exports have diminished from over 50 percent of world trade in 1990 to just over 40 in 1999. Nevertheless, Western European textiles have increased its shares of exports to the "rest of the world" as shown in table 4.2 below. These increases are associated with exports of textiles to the regions where the Western European clothes are sewn e.g. Eastern Europe and Africa[371&372].

Corresponding the diminishing importance of European textiles, the Asian trade has increased. Again the international trade-patterns reveal that most trade is performed within a region: intra-Asian trade in textiles (36,4 billion $) made up for 25 percent of world trade. Trade within this region relates to increasing productions and exports by China, to substantial regional purchases and re-exports by Hong Kong, and to the increasing purchasing powers of Japan. Asian textiles have done very well, which can be related to the success of Chinese producers that exported for approximately 13 billion $ worth almost equal to 9 percent of world exports.

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[370] www.just-style.com (2001).

[371] "Globaliseringens årsager og konsekvenser" (1999) (The Causes and Consequences from Globalisation), HTS Kartellet, available at www.hts.dk/pjecer, January 2000, pp. 1-74.

[372] Graziani, Giovanni (1998): "Globalisation of Production in the Textiles and Clothing Industries", in BRIE Working Paper, No. 128, available at http://garnet.berkeley.edu/~briewww/pubs/wp, November 1999, pp. 1-23.

Table 4.2: Regional exports and imports in textiles, %-share of world exports, 1990 and 1999.

Exporter	Western Europe		Asia		North America	
Importer	**1990**	**1999**	**1990**	**1999**	**1990**	**1999**
Western Europe	41,5	28,9	5,7	5,4	1,4	0,9
Asia	3,0	2,4	20,4	24,6	1,1	0,8
North America	2,4	2,4	3,7	4,7	1,6	3,1
3-Bolck trade	**46,9**	**33,7**	**29,8**	**34,7**	**4,1**	**4,8**
Rest of the World	6,3	9,0	5,5	7,1	1,4	3,0
World trade	**53,2**	**42,7**	**35,3**	**41,8**	**5,5**	**7,8**

Source: www.wto.org (2001).

North America is the worlds' leading net-importing region and has substantial textile imports from Asia; intra-American trade is negligible at 3 percent in 1999. North American exports only contributed with 8 percent of world trade in textiles, which is an increase that is related to exports of materials for belabouring in Latin America. Low exports of textiles further indicates that the North American clothing imports are not based on outsourcing of single production-steps, but relies more on total outsourcing patterns.

Table 4.3: World leading exporters and importers in textile, %-share of world trade, 1980-1999.

	Exports				**Imports**		
	1980	**1990**	**1999**		**1980**	**1990**	**1999**
China	4,6	6,9	8,8	USA	4,5	6,2	9,2
Hong Kong	-	-	8,3*	Hong Kong	-	-	8,1*
Germany	11,4	13,5	8,0	China	1,9	4,9	7,1
Italy	7,6	9,1	8,0	Germany	12,1	11,0	6,4
South Korea	4,0	5,8	7,9	UK	6,2	6,5	4,8
Taiwan	3,2	5,9	7,4	France	7,2	7,0	4,4
USA	6,8	4,8	6,4	Italy	4,6	5,7	3,7
France	6,2	5,8	4,8	Mexico	0,2	0,9	3,1

Source: www.wto.org (2001). * Hong Kong only hold minor exports and imports at 0,8 and 1,0 percent respectively, however there are substantial re-exports and retained imports approximately 7,5 and 7,1 percent respectively in 1999.

Looking at the individual countries development-trends get more detailed. First of all, it is striking to see so many of the countries being leading exporters and importers at the same time, which suggest wide-scale imports of textiles for domestic belabouring and re-exports of finished fabrics. Secondly, all the major European countries have experienced decreasing importance, and the non-European countries have all increased in importance, which epitomise the struggling conditions of West-European textiles: increasingly textile belabouring is performed in other countries.

Asian textiles have developed remarkably in the past decades. Generally, the Asian countries gain competitive advantages from low labour costs and high technological developments. The labour force has gradually been upgraded through decades of textile productions in the region, and increasingly the Asian companies have applied machinery in production-steps and outsourcing to regional low-cost countries for other functions e.g. to Vietnam. China, South Korea and Taiwan have all developed exceptionally[373]. European textiles that used to be the sole suppliers of high quality fabrics have on the other hand all experienced industrial deterioration reflected in decreasing international sales and employments[374]. Industrial declines have been most engraving to the German industry but also to the Italian and French. Denmark on the other hand has done quite well as revealed below.

World trade in textiles grew by 4 percent a year in the 1990s but were actually reduced by 1 percent annually in the 1996-1999 period. Important factors are stagnating demands for clothing and subsequently for textiles in Western Europe, and increasing sourcing of textiles from Non-European countries. European slow-down has delivered severe blows to textile industries in Austria, Germany and Greece, and recently to Italy and UK as well. However, some countries have managed to increase their exports e.g. Poland, Spain and Turkey, which gain primary competitiveness from cheap labour supply.

Reductions in Western European textile export are corresponding reductions in imports. Again, the increasing exports by Asian countries are coupled with increasing imports. Relative values of imports have been decreasing for the major Western European countries without exception. The major suppliers for Western Europe are in order Turkey, India, USA and China[375], but the Baltic region is also important as exporters.

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[373] www.just-style.com

[374] Hartman, U (1984): "Experiences in restructuring the textile industry in West Germany and some other industrialised countries", in The Textile Institute, Annual World Conference: "World Textiles: Investment, Innovation, Invention", London, pp. 1-46.

[375] Data from Centre for the Economic Observation of Textiles, reported by www.just-style.com, (2001).

Table 4.4: European exports of textiles, selected countries, 1990-1999.

	Value Million $				Average growth rates			%-share in total merchandise exports	
	1990	**1996**	**1999**		**1990-99**	**1996-99**		**1990**	**1999**
World	104270	151060	147920		4%	-1%		3,1	2,7
EU (15)	50795	60040	57437		1%	-2%		3,4	2,6
Austria	2083	2005	1532		-3%	-9%		5,0	2,4
Denmark*	769	840	1034		3%	5%**		N.A.	2,6
France	6057	7303	7030		2%	-1%		2,8	2,3
Germany	14033	13787	11885		-2%	-5%		3,3	2,2
Greece	500	507	411		-2%	-7%		6,2	3,7
Italy	9492	13205	11783		2%	-4%		5,5	5,1
Netherlands	2911	3240	3860		3%	6%		2,2	1,9
Poland	284	562	727		11%	9%		2,0	2,7
Portugal	1328	1610	1694		3%	2%		8,1	7,1
Romania	125	167	165		3%	0%		2,5	1,9
Spain	1497	2886	3142		9%	2%		2,7	2,9
Turkey	1440	2722	3478		10%	9%		11,1	13,4
UK	4379	5399	4484		0%	-6%		2,4	1,7

Source: Belabouring of statistical data from www.wto.org (2001) and from Statistics Denmark (2000)[376].
Notes: *) Figures from Denmark are calculated from statistics provided by Statistics Denmark.
**) Growth rates for Denmark are for the period 1995-1999.

Clothing

Patterns of world trade in clothing resemble the patterns identified in trade with textiles; early 1980s showed moderate growth, late 1980s explosive growth at 17 percent a year, and the 1990s have developed more steadily. Annual growth rate were 6 percent through the decade, which was slightly better than for textiles. Substantial parts of world trade in clothing have been performed as intra-European trade (46,6 billion $), which constituted about 25 percent of world trade in clothing in 1999. However, compared to global levels of clothing trade the intra-European trade has diminished substantially since 1990 where it amounted to more than 35 percent of world trade. Reductions in intra-European trade are also reflected in the exporting position of Western Europe where the shares of world trade have diminished from over 40 percent of world trade in 1990 to just over 30 in 1999. Nevertheless, Western European clothing has increased its shares of exports to the "rest of the world" as shown in table 4.5 below, but basically the Western European clothing industry are left with only on market i.e. Western Europe itself. High levels of quality and product differentiations, which only slowly have become exportable to other regions, mark Western European clothing.

[376] "Danmarks vareimport og eksport" (Denmark's Commodity Imports and Exports) (2000), and Annual Statistical Books from Statistics Denmark, Copenhagen.

Table 4.5: Regional exports and imports in clothing, %-share of world exports, 1990 and 1999.

Exporter	Western Europe		Asia		North America	
Importer	**1990**	**1999**	**1990**	**1999**	**1990**	**1999**
Western Europe	36,1	25,1	13,0	10,6	0,5	0,2
Asia	2,3	1,7	8,1	11,3	0,4	0,3
North America	2,5	2,0	19,5	16,9	0,5	1,4
3-Bloc trade	**40,9**	**28,8**	**40,6**	**38,8**	**1,4**	**1,9**
Rest of the World	2,7	3,6	3,0	3,7	1,3	3,6
World trade	**43,6**	**32,4**	**43,6**	**42,5**	**2,7**	**5,5**

Source: www.wto.org (2001).

In correlation to the diminishing importance of European clothing, the Asian trade has developed substantially better and has outpaced the Western European trade; from holding equal shares in 1990 the Asian share of world markets is above 40 percent, whereas Western European share is just over 30 percent (in 1999). Unlike Western European clothing, which are expensive quality-items primarily exported to other Western European countries, the Asian exports are much more differentiated with both low quality, low cost items and middle quality products[377]. Trade is also more dispersed: 17 percent of world exports going from Asia to North America and 11 percent to Northern Europe. Intra-Asian trade constituted 11 percent in 1999. Through the 1990s the trade patterns have shifted for the Asian clothing with increasing importance of intra-Asian trade related to increasing levels of regional outsourcing.

North America is the world's largest net-importer of clothing, and has substantial imports from Asia; intra-American trade is negligible at less than 2 percent. North American exports contributed a merely 6 percent to world trade in clothing.

Internationalisation of the clothing industry has, like the textile industry, become evident in the increasing volumes and values traded, and the increasing contributions from inter-regional trade. Internationalisation has been most evident in the reduced importance of Western Europe industry, and trends of globalisation are emerging due to increasing roles of more regions, notably Latin America and Eastern Europe. These trade evidences are also supportive to the theoretical suggestions of industrial developmental traits of regions: initially regions gain control of the manufacturing-processes

[377] www.just-style.com

followed by increasing control upstream and upgrading of the manufacturing-processes through product and process-development[378].

Table 4.6: World leading exporters and importers in clothing, %-share of world trade, 1980-1999.

	Exports				Imports		
	1980	**1990**	**1999**		**1980**	**1990**	**1999**
China	4,0	9,0	16,2	USA	16,4	24,1	30,0
Hong Kong	-	-	12,0*	Germany	19,7	18,2	10,6
Italy	11,3	11,0	7,1	Japan	3,6	7,8	8,4
USA	3,1	2,4	4,4	Hong Kong	-	-	7,6*
Mexico	0,0	0,5	4,2	UK	6,8	6,2	6,4
Germany	7,1	7,3	4,0	France	6,2	7,5	5,9
Turkey	0,3	3,1	3,5	Italy	1,9	2,3	3,0
France	5,6	4,3	3,1	Netherlands	6,8	4,3	2,6

Source: www.wto.org (2001). * Hong Kong only hold minor exports and imports at 5,2 and 1,0 percent respectively, however there are substantial re-exports and retained imports approximately 6,8 and 6,6 percent respectively in 1999.

This developmental trait has been evident for countries like Spain, Portugal, Taiwan and Korea. Other countries have just started similar patterns of development e.g. Poland, the Baltic Countries, Rumania and Turkey. Countries of the future will could be Vietnam, North Africa and former Soviet republics[379].

Looking at the individual countries some these developmental trends get more pronounced. Like the textile case, the international trade in clothing reveals both internationalisation of value chains and large degrees of product differentiations. Internationalisation of value chains is expressed via reoccurrences of 7 out of 8 countries as both major importers of textile and as major exporters of clothing i.e. textiles are imported for belabouring and exported as final or semi-finished clothing. Only exceptions are UK who imports many textiles but does not have any substantial exports of neither textile nor clothing, and Turkey who has substantial exports of clothing to Western Europe but does not import much clothing or textiles. This is explicable by large degrees of domestic supply of textiles and negligible national demands for clothing.

[378] Coró, Giancarlo & Roberto Grandinetti (1999): "Evolutionary Patterns of Italian Industrial Districts", in Human Systems Management, Vol. 18, pp. 117-130.
[379] Interview results & op cit Audet (1996).

Table 4.7: European exports of clothing in selected countries, 1990-1999.

	Value Million $				Average growth rates			%-share in total merchandise exports	
	1990	**1996**	**1999**		**1990-99**	**1996-99**		**1990**	**1999**
World	108000	164140	186030		6%	4%		3,2	3,4
EU (15)	40782	51332	51371		3%	0%		2,7	2,4
Austria	1168	1390	1257		1%	-3%		2,8	2,0
Denmark	859	1288	1939		9%	14%		2,3	4,0
France	4670	5529	5690		2%	1%		2,2	1,9
Germany	7881	7579	7441		-1%	-1%		1,9	1,4
Greece	1714	1878	1505		-1%	-6%		21,1	13,5
Hungary	375	1135	1312		15%	5%		3,8	5,2
Italy	11838	16172	13240		1%	-6%		7,0	5,7
Netherlands	2188	3053	2631		2%	-5%		1,7	1,3
Poland	384	2373	2199		21%	-2%		2,7	8,0
Portugal	3490	3591	3151		-1%	-4%		21,3	13,2
Romania	363	1559	2044		21%	9%		7,3	24,0
Spain	598	1377	1827		13%	10%		1,1	1,7
Turkey	3330	6067	6516		8%	2%		25,7	25,0
UK	3041	5185	4487		4%	-5%		1,6	1,7

Source: Belabouring of statistical data from www.wto.org (2001).

As with textiles the Asian clothing industry has developed remarkably well in the past decades, related to exceptional performances by a wide set of countries. Initially the Asian countries gain the same competitive advantages in clothing as in textiles i.e. from low labour costs but the countries have developed differently, some with higher degrees of technological developments and increasing labour costs[380]. China, South Korea and Taiwan have all developed exceptionally well obtaining higher levels of quality and increasing levels of national or international outsourcing of labour-intensive functions. And Hong Kong has been remarkable as a transit economy as well as a producing country.

European countries have on the other hand all experienced industrial deterioration reflected in decreasing international sales and employments[381&382]. Industrial declines have been most evident for Italian industry but also for the German and French industry. Denmark again has beaten the European trend and done quite well as revealed in table 4.7.

[380] Campbell, Alexandra (1998): "Cooperation in international value chains: comparing an exporter's supplier versus customer relationships", in Journal of Business & Industrial marketing, Vol. 13, pp. 22-39.
[381] Op cit: Hartman (1984).
[382] Op cit: Audet (1994).

Whereas world exports of clothing grew by 6 percent in the past decade, international trade were marked by Western European slowdowns especially in the last 2 years. The receding European economy has influenced most of the European countries, and some have experienced industrial recessions throughout the 1990s, which suggest major industrial crises and transitions. Prolonged periods of decreases have been evident for Greece, Germany, and Portugal, and the latest recessions have been most evident for Greece, Italy, Netherlands, Portugal and the UK. Whereas Germany has experienced moderate levels of industrial decline, the declines have been much more severe for Greece and Portugal as important parts of their national exports are found within the clothing industry. On the other hand, quite a few countries have increased exports throughout the decade e.g. Poland, Romania, and Turkey who all have gained orders due to low labour-costs in sewing. These countries have received increasing orders as traditional sewing areas in Portugal and UK have become too expensive.

Denmark stands out as an exception: despite competing on products of medium to high quality products the exports have actually increased. Denmark's competitive advantages relate to good qualities at reasonable prices provided through mechanisation and digitisation of operations and outsourcing of labour-intensive functions to neighbouring countries[383]. The recorded growth rates in exports coupled with increasing rates of imports of clothing reflect Denmark's increasing importance as a transit economy very much like the Asian case of Hong Kong.

General reductions in the share of Western European clothing-exports are not related to any substantial reductions in import levels, indeed clothing imports in the EU have risen annually by 5 percent in the 1990s and by 2 percent in the past few years. Western European imports are primarily received from other Western European countries (50 percent of imports in 1999), from Asia (30 percent), from Eastern Europe (10 percent) and from Africa (8 percent). The major suppliers for Western Europe are in order China, Turkey, Hong Kong and Tunisia, but the Baltic region is also important. USA is by far the largest single importer of clothing in the world with 30 percent of world imports. North American imports are coming from Asia (55 percent), Latin America (30 percent) and Western Europe (6 percent). Asia holds remarkable low levels of clothing imports related to low income levels and ample regional supplies, only Japan had major imports for final consumption, and Hong Kong for re-exports.

[383] Interview results.

Summary

Increasingly the textile and clothing industry has become globalised reflected in changing patterns of international division of labour and trade within the past decades. Evidently the West European textile industry has experienced receding sales related to rising European labour costs and development of regional suppliers in Asia, Eastern Europe, Turkey and North Africa. West European clothing is also getting exposed to increasing competitions from other regions, notably Asia.

Competitive strategies within the clothing and textile industry are dividable into provisions of low cost, low quality items and provisions of high qualities at high costs[384]. Rising labour costs in Western Europe and international competition have reduced the competitiveness of former low cost countries e.g. Portugal and Greece that are loosing orders to Eastern Europe. Competitive strategies of high-quality products, which mark most Western European provisions, have led to industrial recessions with the decreasing European demands. Denmark however stands out as an exception: increasing export-levels of medium-to-high quality items. This has been obtainable through intensive outsourcing patterns with neighbouring low-cost countries and with Asia.

4.4. Danish Textile and Clothing District

National production of textile and clothing has been an important activity firstly to the Danish rural population and, with the industrialisations, also to the city-population. Substantial parts of the industrial employment have been low-skilled women who have provided the manual labour needed for textile production and in manufacture e.g. sewing. Industrial restructuring since the 1970s have been exceptionally harsh on the low-skilled employees. Firstly, mechanisations have rendered much un-skilled labour superfluous in textile production, and secondly rising labour costs have triggered international outsourcing of labour-intensive functions.

Internationalisation of the Danish textile and clothing industry has flourished in the post WWII period in which trade-barriers have been reduced and European demands and consumptions have grown. Relying on international markets for supplies and sales the Danish industry has been fully exposed to the trends in international economy and been forced to adapt accordingly. Adaptations have centred on specialisation-processes, strengthening of core competencies coupled with network-structures in production, increased mechanisation and digitisation of operations, and finally outsourcing of labour-intensive functions abroad. This section contributes with an outline of the historic conditions for the

[384] Op cit: Gereffi (1999).

Danish textile and clothing industry, followed by key features that characterise the present viability of the Herning-Ikast industrial district.

Historical Contingents

Denmark has like most other countries had a long tradition for producing textiles and manufacturing clothes. This tradition stems back to pre-industrial work relations between landlords and the peasantry, who was enforced into the routinised work-relations that preceded the early industrial employment-structures of supervised work at correction-houses, schools, workhouses etc[385]. Pre-industrial production was primarily manual and empowered by humans or by waterpower. Introduction of more advanced power-sources led to the reorganisation of production-processes known from the industrial revolution with increasing mechanisations and divisions of labour. Pre-industrialised markets were characterised by limited transport tools and restricted infrastructures leading to evident geographical limitations to trade. Productions of Danish textile and clothing had to be located near the final markets e.g. the urban areas or where the needed resources were plentiful i.e. early Danish productions were situated in either Copenhagen or the rural area of Herning and Ikast in Western Jutland. Since then changes in composition of demand e.g. end to Danish naval powers and decreasing needs for sails, changes in labour markets e.g. increased labour-costs especially in urban areas, and better transportation e.g. improved infrastructure, have doomed the textile and clothing industry in Copenhagen[386].

Industrial production in the Herning-Ikast area has on the other hand shown its viability and businesses in this area have sustained their competitiveness. The industrial development in this area were started by abundance of resources such as plentiful labour coming from the de-populated agriculture, plentiful raw-materials as wool from the local farmers, and plentiful water-energy from numerous rivers and streams, and low transportation costs from a fine central location enabled by developing infrastructures[387&388]. Despite deterioration of some of the initial conditions that triggered the development of this industrial cluster, the area has remained competitive due to emergence of many small and medium sized firms that have been compelled to compete and constantly to be innovative leading to continuous increases in productivity. Firms in the region have specialised their activities and concentrated in providing high-quality products and services, concentrated on core competences and

[385] Op. cit: Harnow, (1999).
[386] Op cit Christensen (1996).
[387] Kristensen, Peer Hull (1992): "Industrial districts in West Jutland, Denmark", in Frank Pyke & Werner Sengenberger (eds.): "Industrial districts and local economic regeneration", International Institute for Labour Studies, Geneva, pp. 122-173.
[388] Op cit: Illeris (1992).

increasingly become networked; they purchase and outsource critical functions from/to other firms. Despite the persistent competitive pressures the local businesses also reveal some degrees of cooperation on product development and technology[389&390]. Industrial activity resembles the characteristics of industrial districts: jointly the firms perform all steps of the value chains but individually they only perform a narrow range of tasks, personalised relations govern interactions, and they share the same regional conditions regarding a skilled labour force, good transportation, financing etc. The success of the area has also been related to the good performances of supporting industries notably the furniture industry[391].

Mechanisations and digitisations of operations have marked the recent developments in the Danish textile and clothing industry. The Danish production-conditions are related to a well trained but expensive labour-force, which on one hand makes it possible to apply increasingly, complicated and advanced technologies, and on the other hand compels businesses to substitute labour with capital. Hence, Danish textile productions have become increasingly mechanised through applications of computerised machinery in spinning, weaving, knitting etc. Likewise, the Danish manufacture of clothing has become dependent on digitised CAD/CAM-technologies in functions like designing, knitting and cutting[392]. Computers play an increasing role in management operations both for internal production-management and for organising interactivity with other firms such as distribution and supply chain management. Digitisations of processes have enabled speedier production-processes, higher qualities, reduced wastes etc., and EDI-messages and Internet-based communications have been instrumental in improving inter-firm co-operations. Networking and applications of ICTs and DMM-technologies have enabled a very high responsiveness to market alterations: value chains within the district excel in provisions of small-batch speedy deliveries[393].

Increasing consumer spending and demands have fertilised the markets for large-degree product differentiations, seasonal collections and segmentations of markets[394]. Provisions of the right products at the right time are essential to achieving good prices and profits, which the Danish industry has accomplished through decades of learning, specialising, networking, and increased applications of technologies. Increased levels of mechanisation have been developing in correspondence with

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[389] Op cit: Maskell & Malmberg (1995).
[390] Nielsen, Kent (1993): "Industrielle netværk" (Industrial Networks), Systime/GAD, Herning, Denmark.
[391] Op cit: Illeris (1992).
[392] Interview result.
[393] Interview result (2000).
[394] Byrne, Chris (2000): "The Industrial and Social Impact of New Technology in the Clothing Industry into the 2000s", available at www.davidrigbyassociates.com/articles, February 2000, pp. 1-21.

improvements in the labour force: increasing educations and vocational trainings of employees have emerged together with increasing unit cost of labour. The joint improvements in technology and the labour force have meant more skilful operations and higher-quality processes, which have lifted the standards of Danish textiles and clothing substantially. Competitiveness of this industry is increasingly based on medium to high-quality products that are provided at reasonable prices, enabled by mechanisations and outsourcings. Equally important to the economic success are the timing of deliverances, where the mechanisation and digitisation of processes have reduced the time spend in production-cycles, time-to-market, improved forecasting abilities and reduced costs of logistics. The competitive situation of the individual firms hinges on correct estimates of emerging demands and forecasts based on abundant information received from retail e.g. enabled through scanners, electronic points of sales. Shared information structures between business partners have developed alongside personalised relations, EDI-message systems, and electronic infrastructures.

Danish retail sector has like most other Western European economies experienced increasing levels of centralisation within the past decades[395]. Centralisation has been expressed by diffusions of retail chains that increasingly compete with specialised stores. Specialist outlets in addition get exposed to rising competition from online sales and supermarkets that offer convenient shopping experiences, and by the detail-stores that provide spot-markets for clothing[396]. Specialist retailers have increasingly specialised their outlets, targeting market segments. Concurrently they have engaged in tighter cooperation with manufacturers e.g. franchised outlets and concept stores. Some shops have become directly own by the manufacturer who gain a direct access to market information and better analyses. Cooperative structures also include vendor managed inventory and sales e.g. at Sallings and Magasin. A basic feature of the tighter cooperation is the shared information-systems and high application levels of EDI-messaging often initiated by the major retail companies[397].

[395] Mattila, Heikki (1997): "Expected changes in European garment retailing and their impact on garment and textile production", in Proceedings of World Conference of the Textile Institute, Vol. 1, pp. 140-149.
[396] Christensen, Clayton & Richard Tedlow (2000): "Patterns of disruption in retailing", in Harvard Business Review, Vol. 78, pp. 42-45.
[397] Interview result, 1999.

Table 4.8: Domestic production and employment in textile and clothing industry Prices in Mio. Dkr., 1985-1999.

	1985	1990	1995	1999
Domestic Production				
Textile	8693	7721	7275	7114
Clothing	4456	4625	4850	4758
Textile & Clothing	13149	12346	12125	11872
Textile share of T & C	66%	63%	60%	60%
T & C share of total industry	4,1%	3,5%	3,3%	* 3,1%
Domestic employment				
Textile & Clothing	32907	30376	23900	16211
T & C share of total industry	8,7%	5,7%	5,0%	3,6%

Source: Statistics Denmark. Note: *) share of industry turnovers.

Increasing cooperation and integration between manufacturer and retailer are pursued in order to gain enhanced knowledge levels on product possibilities, fashion and market trends, and to impact product developments[398]. Enhanced information-levels provide better tools for getting the right products at the right time, and for providing services to customers. In addition the feedback mechanisms enable better learning structures. Integrations are however not always harmonious: large retailers dictate conditions of trade for minor suppliers e.g. EDI-standards and barcoding, and in other circumstances suppliers may determine price-levels, which reduces the competitiveness of the retail sector[399].

Ever since the restructuring of the industry from the early 1970s the domestic textile and clothing industry has contributed less and less to industrial production and employment. Domestic manufacture of clothing has been increasing until the mid-1990s, whereas textile-production has been decreasing. Differences in growth rates have altered the relative importance of the two sectors, where textiles grew faster than clothing until 1980 until it composed ¾ of this industry's output. Since then the clothing sector has regained some composure and now contributes with 40 percent of production. Productivity levels measured as domestic production per domestic employee were substantially lower in the textile and clothing industry than the industrial average in the early 1970s i.e. about half. Since then the industry has outsourced labour-intensive functions and mechanised processes, and productivity levels have now reached the industrial average.

[398] Interview results.
[399] "Konkurrenceredegørelse 2000: Konkurrence I detailhandlen" (Competition report 2000: Competition in the retail sector) (2000), avaliable at www.ks.dk/publikationer/2000/kr2000 January 2001.

Since the mid-1970s the blue-collar employment has decreased by 60 percent, whereas the white-collar employment after a 30 percent reduction in the 1970s has remain largely constant. Total employment in this industrial segment in the late 1990s is less than 4 percent of national industrial employment, and is distributed with about 60 percent in textiles, nearly 40 percent in clothing, and less than 5 percent in leather and shoe industry. The distribution of employment in textile and clothing has changed evidently during the past 15 years, which have impacted productivity levels. In the mid-1980s the clothing and textile sectors employed equal numbers of employees but domestic output and productivity per employees were double the ones in clothing. By 1999 the productivity per domestic employee in clothing has surpassed the productivity-levels from textile-production. This remarkable development has only been possible through international outsourcing of labour-intensive functions and extensive applications of digitised information and production-technology. International outsourcing of labour-intensive functions have impacted the national employment-relations in two ways; industrial employment been reduced substantially during the past 30 years, and reductions in domestic employment have primarily hit the blue-collar workers.

District Structures

Danish productions of textile and clothing are primarily performed within a set geographical area in Western Jutland i.e. around the cities of Herning, Ikast and Brande[400]. Production within this region has a historical precondition, but despite an end to some of the initial competitive advantages the area has maintained its high levels of innovation and entrepreneurship, and continuously show improved levels of quality and productivity. Business structures in this area resemble the characteristics from industrial districts e.g. large proportion of small and medium sized enterprises (SMEs), high contribution to national production and local employment, and structures of cooperation alongside competition.

Employment Structures

Industrial organisation of the Danish textile and clothing has been orientated towards the SMEs for decades. Organisation of Danish industry in general reveals that there are only few very large companies of more than 1000 employees; indeed the average size of firms has been decreasing and is now quite low i.e. 23 employees in 1998. The average size of firms in textile and clothing has followed the trend of diminishing unit-size and remained smaller through the last 30 years.

[400] E.g. the op cit Illeris (1992), Kristensen (1992) & Maskell (1995).

Table 4.9: Employment structures in Danish textile and clothing industry, 1970-1998

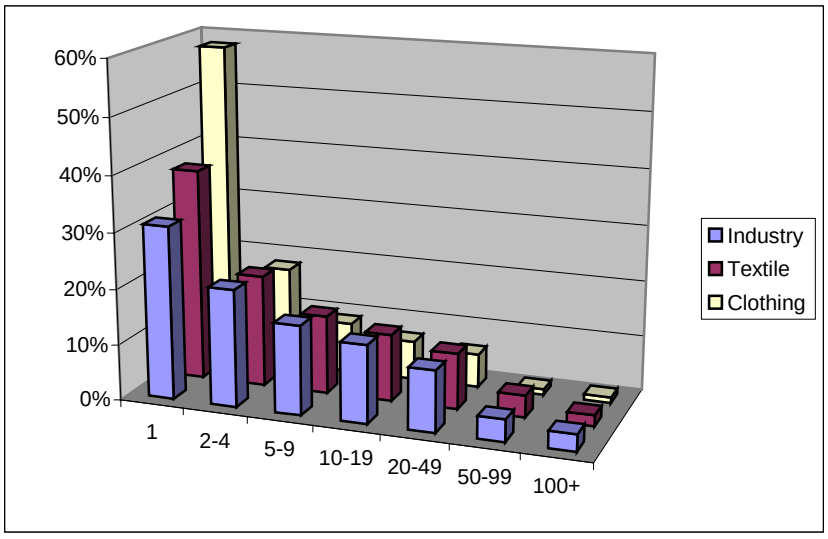
	1970	1975	1980	1985 *	1990	1995	1998
No. of firms	933	815	658	1.745	2.827	2.361	1.615
Share of industry firms	14%	12%	10%	8%	9%	9%	7%
Average size	47	38	38	19	11	10	10
Indus. average size	62	58	59	18	18	19	23

Sources: Maskell (1984) and Statistics Denmark at www.dst.dk.
Note: *) figures before 1985 exclude industrial activity of firms smaller than 6 employees.

Employment in both textile and clothing is based on smaller units than for total industry, and that especially the manufacturing of clothing is situated in small business units. A high rate of one-man firms seems remarkable to these industrial segments with 38 and 58 percent of all firms respectively in 1996. ¾ of all firms in clothing have less than 5 employees whereas the corresponding figures are 60 percent for the textile industry and 50 percent of industry in general.

Business-units with 20 to 49 employees contribute substantially to employment for both textile and clothing, which suggest that industrial structures favour this unit-size; the units reach both advantages from specialisation and avoid structural rigidity. In 1998, the average size of firms in the textile industry was 14 employees. Though the average size is well below the total industry's average of 23 employees, their sizes are about double the average size of firms in the clothing industry who had an average of only 7 employees.

Figure 4.3: Distribution of firm by size, 1996



Locality

Besides the evident importance of SMEs in the textile and clothing industry, the industrial organisation also reveals high importance of geographical proximity i.e. major parts of the Danish production of textile and clothing is found in the Herning-Ikast area. Below is an outline of the local contributions and importance of this industry in Herning, Ikast, Brande and neighbouring municipalities i.e. the district. Industrial production in this industry is highly concentrated around these cities and the geographical constitution of the district resembles the political construction of the local county: Ringkøbing County.

Whereas Ringkøbing County constitutes about 10 percent of the nation's surface, it is only inhabited by 6 percent of national population, which is due to rural geography and low population density. Proportions of national employment and workplaces are slightly higher in the County than population figures suggest. When it comes to production of textile and clothing the County constitutes about 1/5 of all workplaces and nearly 2/5 of the employment: the County contributes more to textile and clothing industry than its relative little size should suggest. Indeed, large shares of national employment of this segment is located in this region suggesting good regional conditions such as the labour market and affluence of supporting institutions. Further, the average size of textile and clothing businesses is substantially higher than the national average i.e. 19 versus 10 employees in 1998: the County contains almost half the national firms in the industry sized 50 to 99 and those over 100.

Table 4.10: Employment structures of the textile and clothing industry (1996-97)

	Workplaces			**Employment (x 1000)**			**Employment/workplace**		
	Total Industry	Industry	T & cloth.	Total Industry	Industry	T & cloth.	Total Industry	Industry	T & cloth.
Denmark	300.742	25.460	1.928	2.895	517	18,7	9,6	20,3	9,7
County	18.911	1.797	368	158	43	7,1	8,4	23,9	19,3
County share	6 %	7 %	19 %	6 %	8 %	38 %	-	-	-

Source: www.dst.dk (2000).

Whereas textile and clothing forms 4 percent of national industrial employment, it forms about 15 percent of employment within the County: about 1/5 of County workplaces are within this industry.

There can be no doubt that textile and clothing is concentrated in this County and in this district, that this particular industry is a major activity within the district, and that there is a correlation between business size and location within the area. The combination of many larger firms inside the district indicates that there exist extraordinary good conditions for industrial growth. Likewise, the relative high rate of small firms outside the district indicates that the conditions outside are rough so firms only grow slowly or move to the district. There is no indication for higher birth rates of firms outside than inside[401].

Regional Structures

Businesses in the district gain competitive advantages from continuous innovative activities and specialisations[402]. The industrial district is characterised by a wide set of special relations and institutions that impact the local interaction of firms and shape the competitive nature e.g. political structures, position of employers' organisation, regional service institutions, regional provision of technologies, distribution and learning structures.

Herning-Ikast district by and large constitutes the same geographical area as the county. Further, as this industry has become so important to local production and employment, there is much focus on this industry by the local politicians, and the interests expressed by the textile and clothing industry influences much of the regional policy[403]. Other important cooperative structures relate to the role of labour organisations where trade unionism is quite high and at least in later periods have been cooperative[404]. Employers' federation i.e. Federation of Danish Textile and Clothing is as the only employer federation located outside Copenhagen, indeed it is located in the capital of the district: in Herning[405].

Besides the political structures there also exist a set of institutions that assist knowledge-formation and information sharing in the region, just as there are special localised provisions of production-machinery and ICT-services. The employers' federation alongside the regional industrial council (Erhvervsrådet Herning, Ikast & Brande) collects and distributes much information targeted towards the textile and clothing industry[406]. These information services relate to market and trend analyses,

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[401] Op. cit. Maskell (1984).
[402] Op cit Kristensen (1992).
[403] "Erhvervsministeriets forsøg med erhvervsknudepunkter" (Experiment with regional industrial centres by Ministry for industry) (1998), Erhvervsfremme Styrelsen, available at www.efs.dk/publikationer, February 2000, pp. 1-27.
[404] Op cit: Illeris (1992).
[405] www.textile.dk (2001).
[406] www.hie.dk (2001).

legal information, commercial events etc. In Herning there also exist a large exhibition arena where major parts of Danish textile and clothing products become displayed. Regional training programmes have also been established that seeks to enhance local industrial skills, operational skills, IT-skills, environmental knowledge etc[407]. And alongside these structures, Lectra as the major supplier of machinery for Danish textile and clothing industry is located in this region, and some of the major ICT-providers for commercial needs are found here[408&409]. The region is also enriched by a well-functioning transport sector, by a highly skilled labour force, and personal networks influence much of the business interaction[410].

Specialisation

A final attribute of industrial district is the high degree of innovative-activity and specialisation of firms, on which there is only limited statistical material[411]. However, looking at the members of the Federation of Danish Textile and Clothing and their use of Internet-based technologies, some impressions of the specialisation levels are revealed[412]. The 263 members have been analysed with respect to different attributes like number of value-adding functions, age, size, location etc. This analysis reveals that businesses both inside and outside are quite similar with respect to age and size. As compared to a national average there are a relative high proportion of clothing-companies inside the district and fewer textile-producers. Service-providing firms that belabour textiles or clothing e.g. sewing, colouring, ironing, control are well presented within the district. A powerful indicator for degrees of specialisation is found in the number of value-adding steps: Businesses perform fewer functions and are hence more specialised within the industrial district than outside, especially the clothing companies within the district are more specialised and perform fewer functions individually[413].

The average profile of firms within and outside the district is quite similar except from the application of Internet-based communication-tools. Applications of e-mail are the same both inside and outside the district, but firms within the district are more likely to apply some form of homepage i.e. 65 percent inside had web-pages compared to 54 percent outside. However, the firms outside the district have come the furthest in their development of functionalities for the web-pages: there are relatively

[407] www.tic.dk (2001).
[408] www.lectra.dk (2001).
[409] www.edbgruppen.dk (2001).
[410] Op cit: Kristensen, Peer Hull (1992).
[411] Op. cit: Maskell (1984).
[412] Own research, December 2000, see appendix B for further details.
[413] See appendix B.

more firms outside the district that support online sales and provide key-information about products and the business[414].

Analysing the collected data through regression-analyses it becomes possible to explain substantial parts of the businesses web-based information-tools. A regression shows that the more specialised the business i.e. the fewer functions and the fewer brands it promotes the more likely it is to apply the web-based tools. And the economic performances are important too; higher profits lead to higher scores. However, the explanatory powers of the number of brands must be questioned as another regression reaches the opposite result. This regression instead emphasises the position of the business and its position in the value chain. Despite having more businesses with e-mail and web-pages, the businesses within the district generally score lower on the provision of web-based communication-tools than those outside. This is due to a quite un-advanced stage of application within the district: the district-based businesses probably apply other personal communication-structures. This regression also shows that the earlier the business is located in the value chain the more likely it is to provide web-based communication-tools. This suggests that notably the district-based clothing-companies do not apply web-based communication and instead rely on personal meetings etc.[415].

Internationalisation

Danish textile and clothing industry has been subject to major degrees of internationalisation in past decades, expressed in two dual trends. At one hand, the consumption has become international through internationalisation of markets, improved distribution and increased trade. And at the other hand, employment relations in the Denmark have been subjected to major increases in labour-costs. Combined with only limited technological innovations in functions like sewing, the production has increasingly become outsourced internationally: much of Danish clothing is now sewn abroad[416].

Development of Danish textile and clothing industry from 1950 to the late 1990s indicates increasing levels of domestic production, imports, exports, and an increasing home market[417]. Throughout the period domestic production and home market have grown at about 4 percent annually, which is only about half the registered growth in international trade. Especially the 1960s, 1970s and 1980s have shown high growth rates on all accounts; recently the domestic production has stagnated just as the growth rates of the home market have slowed down. However, both imports and exports keep rising.

[414] See appendix B, regression 2.
[415] See appendix B.
[416] Own results.
[417] Calculated as the values of domestic production and imports deduced exports

Table 4.11: Danish textile and clothing industry

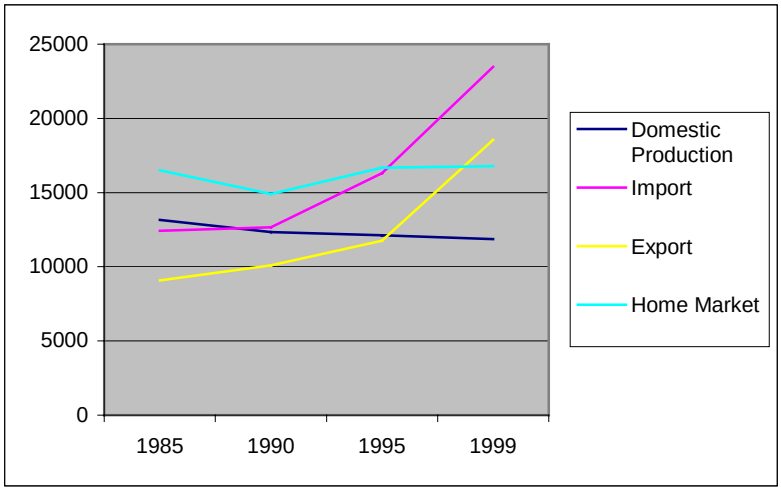
Values in Mio. DKr. and %-growth rates, 1950-1999.

	1950	**1960**	**1970**	**1980**	**1985**	**1990**	**1999**
Domestic production	1755	1709	3462	7125	13149	12346	11872
Imports	1011	1103	2657	6149	12430	12666	23460
Exports	104	306	1382	4024	9086	10101	18557
Home market	2662	2506	4736	9251	16492	14911	16775
	1950-60	**1960-70**	**1970-80**	**1950-80**	**1985-90**	**1990-99**	**1985-99**
Domestic production	0%	7%	7%	5%	-1%	0%	-1%
Imports	1%	9%	9%	6%	0%	7%	5%
Exports	11%	16%	11%	13%	2%	7%	5%
Home market	-1%	7%	7%	4%	-2%	1%	0%

Sources: Maskell (1984) and Statistics Denmark (2000). Note: Industry figures exclude leather and shoes, and the figures before 1985 exclude industrial activity in firms smaller than 6 employees, and are hence not easily comparable to the more recent data.

Development of Danish value-added in textile and clothing production has shown continuous growth from approximately 1955 and until 1980. Since the mid-1980s the industry has been faced with hick-ups at the home market as well as in its major export market: Germany. The downturn that faced the industry then still has a grip in the domestic production, but the international trade seems to have regained its former momentum.

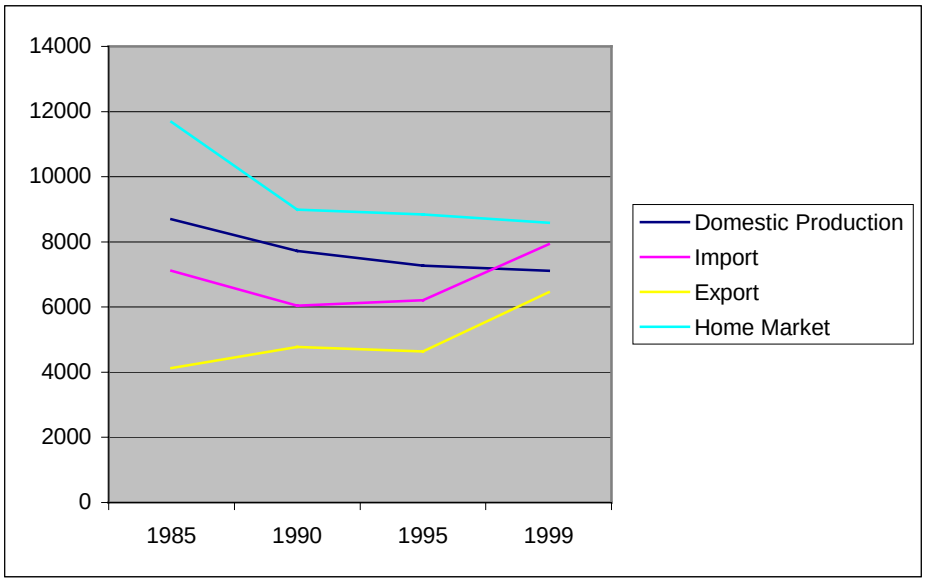
Figure 4.4: Trade in Danish textile and clothing industry, 1985-1999, Mill. DKr.



Internationalisation of production and consumption has impacted the two industrial segments differently. Domestic productions of textiles continuously out-perform the clothing manufacture, but the home market and international trade in clothing has grown evidently faster, and clothing is now contributing more to international trade than textiles.

Domestic productions of textiles have been doing quite well and continuously the domestic provisions have exceeded imports, at least until the mid 1990s. Recessions in the Danish market for textiles have been evident from 1985, since then the values of home market have been dropping. The poor performances relate to receding growth at the major sources for domestic demand: clothing and furniture industry, and increasing competition from abroad. Until 1985 the national production of textiles grew steadily, but decreasing demands abroad shifted the trend and consequently production and imports diminished. Both imports and exports have since regained its high rates of growth even though the home market has experienced slower growth rates.

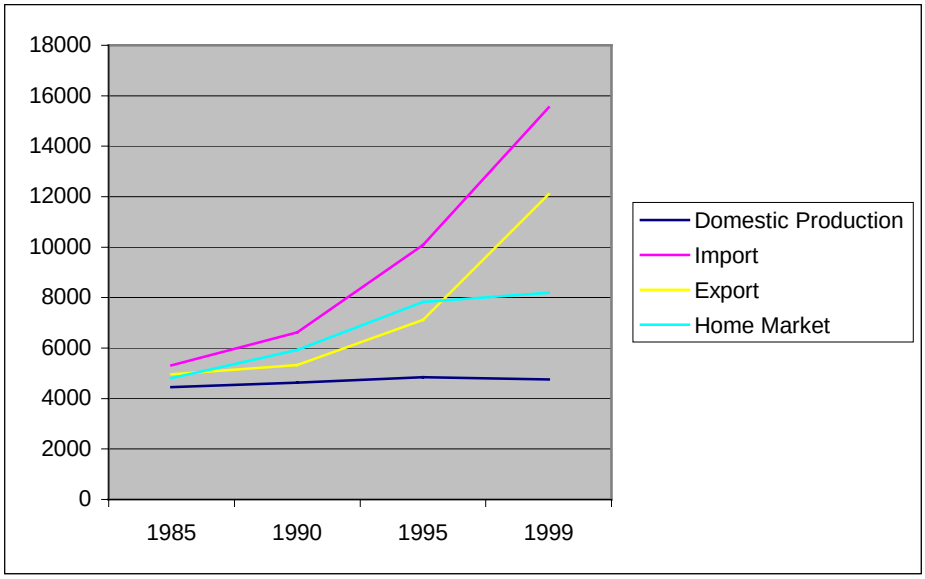
Figure 4.5: Trade in Danish textiles, 1985-1999, Mill. DKr.



Domestic demands for clothing have been increasing steadily, and picking up speed from the mid 1980s. Home markets have increased continuously and now nearly has the same size as the home market for textiles, however the composition of the clothing industry is different from the textile industry.

Increases in the home market for clothing have not been matched by domestic productions, which have remained constant. Increases are evident in imports, which are related to increasing domestic and foreign demands i.e. home market and export levels.

Figure 4.6: Trade in Danish clothing, 1985-1999, Mill. DKr.



Again the mid 1980s were the period of transition where productions increasingly became outsourced, and since then demands for domestically produced textiles have decreased. Despite the good export-performances the clothing industry it has remained net importing since the WWII. Though the shifting domestic and international structures have influenced both segments of this industry, there have been major differences in response. In the period 1985-1999 the textile industry has increased its proportion of domestically produced items as a share of the home market from 74 to 83 percent, which is related to a receding home market. Textile exports have performed increasingly well, thus have exports grown from 47 to 91 percent of the domestic production, and exports have risen as compared to the value of the imports. All in all, the textile industry has become much more internationalised, and the international trade i.e. values of exports and imports have grown from 130 to over 200 percent of domestic production.

Table 4.12: National production and international trade, 1950-1999.

	Textile			Clothing			Textile & Clothing		
	1950 *	**1985**	**1999**	**1950 ***	**1985**	**1999**	**1950 ***	**1985**	**1999**
Prod/home market	59%	74%	83%	92%	93%	58%	66%	80%	71%
Export/production	7%	47%	91%	2%	111%	254%	6%	69%	156%
Export/import	10%	58%	81%	22%	93%	78%	10%	73%	79%
International.	85%	129%	202%	13%	231%	581%	64%	164%	354%

Sources: Maskell (1984) and Statistics Denmark (2000).
Home market = domestic production + imports – exports.
Internationalisation = (imports + exports) / domestic production.
Note: *) Industry figures exclude leather and shoes, and figures before 1985 exclude industrial activity in firms smaller than 6 employees. Figures before and after 1980 are not easily comparable.

Figures from the clothing industry show some similar trends. This part of industry has increased its internationalisation, and from the 1980s onwards Denmark exported more clothing than produced domestically! The remarkable ability to export more than domestically produced is obviously linked to substantial imports that are re-exported with no or little domestic belabouring. Processes of internationalisation have been exceptional in this industry, as imports and exports combined accounted for almost 600 percent of the values of domestic production in 1999. Diminishing importance of domestic production in clothing gets revealed as the domestic provision for the home market has been reduced by a third from 93 to 58 percent since the mid 1980s. International competitiveness of Danish clothing is still high, and export values constitutes 80 percent of import values.

International trade in Danish textiles and clothing reveals two trade-patterns: firstly, products are highly differentiated leading to substantial intra-regional trade i.e. the same countries that provide products demand similar kinds but differentiated products. And, secondly, international distribution of value chains and outsourcing of tasks lead to exports of textiles and imports of clothing from low cost countries. High-quality producers in Western Europe provide most parts of Danish imports of textiles. The major supplier is Germany at 20 percent, and in turn; UK, Netherlands, Italy, France, Belgium and Sweden contributing over 5 percent of Danish imports in 1998. Textile exports basically went to the same markets with one exception: Poland made up more than 10 percent of total textile exports in 1998.

Table 4.13: distribution of Danish Textile and clothing imports and exports, 1998.

	Textile		**Clothing**	
	Imports	**Exports**	**Imports**	**Exports**
20-25 %	D	D	-	D, S
15-20 %	-	-	CH	N
10-15 %	UK	PL, UK	PL	-
5-10 %	NL, I, F, B, S	S, F, N	I, PT, D, HK, UK	SF, UK, NL

Source: Statistics Denmark (2000).
Note: B = Belgium, CH = China, D = Germany, F = France, HK = Hong Kong, I = Italy, N = Norway, NL = Netherlands, PL = Poland, PT = Portugal, S = Sweden, and SF = Finland.

Two clusters of international trading-partners exist for trade in clothing[418]. One cluster relates to other Western European countries that compete on similar product-types but with differentiated designs and

[418] Own analysis.

qualities. These countries are the same Western European trading-partners as found in the textile trade. The second cluster is related to provision of cheaper products at low to medium level qualities. Imports from Poland and Portugal are correlated with outsourcing of labour-intensive functions and Danish exports of textiles. Imports from Asia are on the other hand based on total outsourcing-programme, and do not lead to any noticeable exports of textiles[419]. As with most other Western European clothing producers, there is only one region for export of Danish clothing i.e. other Western European countries.

Summary

Through the last decade the levels of domestic productions in Danish textile and clothing have been fairly constant but the industry has experienced remarkable increases in internationalisation and plummeting domestic employments. The Danish industry has been exposed to rapid increases in international trade, where both imports and exports have increased faster than domestic production: indeed since the early 1990s the exports have exceeded domestic production. International competitiveness and economic viability of the industry has only been possible through unique abilities to adjust to fluctuating market demands combined with extensive relocations of the manual tasks from Denmark to low-cost countries. Unfortunately the extensive outsourcing-patterns have become evident in employment structures: firstly by redundancies in sewing, and lately in reducing employments in textiles.

Superior abilities to predict market-demands and provide high flexibility in provisions are key elements of the industrial viability. Improved market- and fashion-analyses are obtainable through integration with retailers and shared information systems. And flexibility in provisions is obtainable through applied ICTs and DMM-technologies: information sharing in production and logistics, and multimedia files in product development and integration of production. Network-structures found within the Herning-Ikast industrial district are especially important in provisions of speedy small-batch deliveries. Gradually the Danish industry has upgraded its products and increasingly competes on medium- to high-quality products exported to other Western European countries, notably Germany, Sweden and Norway.

Gradual upgrading also marks the regions with which Danish industry cooperates e.g. Portugal and China. As their expertises develop, increasing numbers of functions get outsourced regionally e.g.

[419] Interview result.

local supplies of fabrics, leading to diminishing exports of Danish textiles. Other regions under rapid development but still subject to outsourcing of single functions i.e. sewing are Poland and the Baltic countries. Outsourcing to these countries enables that Danish clothing get assembled at relatively low costs at not too distant locations, which provide medium-speed in production and delivery. These outsourcing structures are based on relatively stable relations, where subcontractors progressively developed their production-skills and -qualities, upgrading the quality of provided products and services.

4.5. Conclusions

Internationalisation of trade in textile and clothing has been governed by two developmental traits. Increasing consumer incomes in Western Europe have led to demands for product differentiations and qualities, which have boosted intra-regional trade in Western Europe. On the other hand, increasing gaps in the international economy have implied growing international differences in factor costs and rising potentials from international division of labour. Despite numerous attempts to limit the international trade and to protect domestic industries, the evidences are uniform: international trade is growing, and Asian textile producers continuously do better as the Western European textile producers and clothing manufacturers do worse.

Despite the gloomy development for Western European textile and clothing, the Danish industry has done relatively well. Danish textile and clothing industry, which is organised in networked structures and gain from location in an industrial district, has managed to increase levels of exports obtained through upgrading product-qualities and through applications of newest production- and information-technologies. However, the competitiveness of Danish industry has only been enabled through extensive outsourcing to low-cost countries, which is reflected in increasing import levels and stagnating domestic productions and falling employments. Production is organised in Denmark and tasks get distributed internationally: total outsourcing to Portugal and Asia, and single step outsourcing to Poland and the Baltic countries.

After some decades of industrial restructuring in the 1970s and 80s the Danish textile and clothing industry performs relatively well compared to other Western European countries. The unique performances of Danish industry are explicable by the networked-structures of specialised businesses in the Herning-Ikast industrial district, high application-rates of EDI-messaging and other ICTs, high-level information sharing, fashion- and market-analyses, product-integration through DMM-

technology notably within the district, highly skilled labourers, high-quality products and designs, and international outsourcing. The exceptional performances of the Danish industry are traceable to good knowledge of the established markets and speedy deliveries of medium to high quality items. Rising levels of domestic labour-costs and international outsourcing mean that the Danish contributions to the industrial value-added increasingly get confined to specialist tasks like designing, administration and logistics. The competitive advantages of the Danish industry relate to its superiority in market-knowledge, demand-forecasting and flexible provisions, which positions Denmark more and more as a trading zone that resembles Hong Kong's position in Asian clothing and textiles. This industry increasingly points to the industrial transformations associated with the service economy: manufacturing-processes get transferred to foreign subcontractors, and Danish businesses confine activities to information processing.

This chapter has shown that industrial competitiveness is not only subjected to general differences in national economic developments but more importantly to the regional compositions of natural resources, labour markets, supporting industries, trade politics, institutions and technological developments. Some of the important technological innovations within textile production relate to mechanisation and automation e.g. in spinning and weaving. Mechanisations of production-technologies are easy to copy, which has led globalisation of these processes. Automation of processes relates more to digitisation of machinery, which requires more skilled labour and has become less diffused. Some regions show evident competitive advantages in providing low cost yarn and fabrics through manual and mechanised processes. Other areas instead provide high quality products produced through automated and digitised processes, where part of the quality relates small-batch, speedy and flexible provisions. General trends are that local industries gradually upgrade their skills and provide better products and services at rising costs.

Production-conditions are somewhat different in the clothing industry, as the sewing-processes have not been subject to any substantial technological advances since the invention of the sewing machine. Sewing remains largely manual and low skilled, and areas with low labour costs hold evident competitive advantages. Other manufacturing-processes have however become highly digitised and automated. Designing has become digitised and data generated by CAD-systems increasingly become transmittable to CAM-systems. Rising compatibility of CAD-CAM-systems and better transmission-abilities enhance production-integrations and constructions of speedy, flexible provision structures. Presently CAD-CAM-file sharing seems confined to the national industry, but is expected later to support communications with Asian suppliers who have high rates of Internet penetration and good

technological skills. Eventually the multimedia-files will also get applied in communication with Eastern European suppliers. Growing abilities to apply multimedia-files does not only enhance the flexibility of supply chains, they also enable better monitoring and feedback structures, which enhances the learning abilities: the more the DMM-technologies get applied, the better the feedback-processes and the abilities for suppliers to learn and upgrade skills. Individual businesses and entire regions develop their skills and improve qualities at rising costs, which make them less suitable for certain provisions, and new suppliers will be searched. Portuguese provisions have been upgrading qualities and become more expensive, and the Danish outsourcing has consequently shifted to less expensive providers in Poland and the Baltic countries. The Portuguese suppliers have developed so will these and will eventually become too expensive: other nations will then take over e.g. former Soviet republics.

Future development of the industry will be marked by a termination of the MFA that has protected industry in developed countries from overseas cheap imports. Gradually the improvements of the production-skills and qualities in Asia and Eastern Europe will enhance their competitive levels, and Western European and Danish industries will increasingly be exposed to competition in the medium to high quality product levels. But it is also likely that rising income levels in Southeast Asia and Eastern Europe will lead to new markets for the Western European industry. Substantial competitive advantages have been generated by West European manufacturers and can be sustained through further branding of products and continuous renewal of skills and flexible structures. International competitions will continuously compel Western European textile producers and clothing manufacturers to reap the benefits from international division of labour and to improve logistics: low labour-costs in different regions of the world, optimise production-structures and distribution-processes, and seek exploitation of any opportunity to make a fast profit and reduce risks. This is accomplished by continuous product differentiations e.g. new designs, functional and intelligent clothing, but also by better market surveillance, demand forecasting and individualised provisions, obtainable through enhanced integrations between value chain segments.

Future economic viability of the Danish industry rests partly with increasing quality-levels and branding of products, and partly with exploitation of established competitive advantages: superior market-knowledge and flexible, speedy provisions. Applications of ICTs and especially DMM-technologies will be important tools for future developments and sustainability of the industry. ICTs and DMM-technologies are essential in reaching automated processes and individualised provisions, but also for international restructuring of value chains, where especially North European and Asian

industries show high degrees of Internet penetration and ICT-skills. With globalisation of information structures and internationalisation of value chains the competitive advantages of the industrial district seem less dependent on manual labour and superior labour markets, but more reliant on superior knowledge-formation and information sharing.

Chapter 5: Textile and Clothing Value Chains

5.1. Introduction

5.2. Value Chain Structures

- Value-adding Steps
- Production Modes
- Outsourcing Structures
- Summary

5.3. Models of Knowledge and Interactions

- Information and Communication Requirements
- Interaction Model
- Summary

5.4. Impacts from DMM-Technologies

- Functions and Processes
- Knowledge-Formation
- Summary

5.5. Conclusions

5.1. Introduction

Production-processes in industry can be divided into a number of minor steps that in combination contribute with the value-added[420]. These steps of value creation often follow a sequential structure where one step automatically leads to the next, performed either inside a single company or distributed amongst a number of companies. Viabilities of such structures of value creation are dependent on the production costs in individual firms and by the organisational abilities value chains: that is, the numerous value-adding steps depend on cross-functional information flows[421]. Composition of distributed value chains suggest that business-units specialise in different activities, and that chains get structured in order to reap the economic gains from specialisations and scales in productions. Competitive abilities hinge on optimising chains structures through enhanced qualities, mass-customisation and flexibilities, redistribution of tasks and substituting inefficient provisions with alternative providers[422].

Crucial to value chain structures is the separation of tasks and transmitability of information. Through increasing applications of ICTs and DMM-technologies, the boundaries for interaction between businesses have been altered: information-processes can increasingly be separated from the physical production steps and transmitted through electronic networks to other businesses[423], new levels of information can be processed reducing time-needs in production and organisation[424], and electronic brokerage and communication-processes enable new modes of identifying potential business-partners and for interactivity between partners[425]. Enhanced applications of ICTs and DMM-technologies enable that information gets distributed to specialist service-providers e.g. for fashion- and market-analyses, and for design-processes. Applications of ICTs also facilitate that functions be distributed to other businesses irrespective of physical distances, which opens up new potentials to reap economic benefits from international division of labour, from specialisations, and from economy of scale[426].

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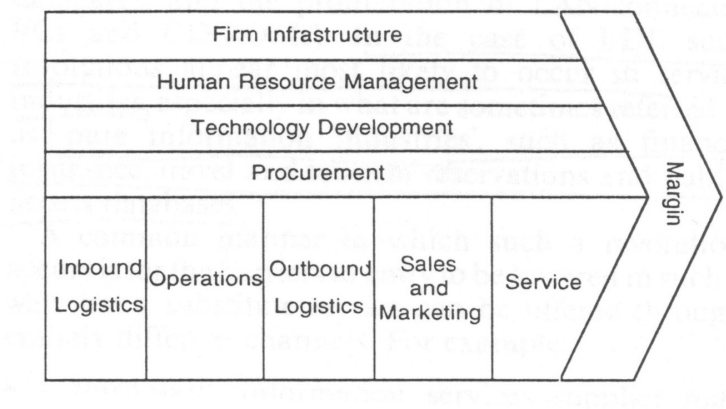
[420] Porter, Michael (1990): ”The Competitive Advantages of Nations”, Free Press, New York.
[421] Clarke, Roger (1992): “A contingency model of EDI’s impact on industry sectors”, in Journal of Strategic Information Systems, Vol. 1, pp. 143-151.
[422] Starkey, Ken & Christopher Barnatt (1997): “Flexible Specialization and the Reconfiguration of Television Production in the UK”, in Technology Analysis & Strategic Management, Vol. 9, pp.271-286.
[423] Rayport, Jeffery & John Sviokla (1995): “Exploiting the Virtual Value Chain”, in Harvard Business Review, Vol. 73, pp. 75-85.
[424] Yasin, M. et al (1997): “An Empirical Investigation of JIT Effectiveness: an Organizational Perspective”, in Omega, Vol. 25, pp. 461-471.
[425] Palmer, Jonathan & Scott Johnston (1996): “Business-to-business Connectivity on the Internet: EDI, Intermediaries, and Interorganizational Dimensions”, in Electronic Markets, Vol. 6, pp. 3-6.
[426] Rhodes, Ed & Ruth Carter (1998): “Electronic commerce technologies and changing product distribution”, in International Journal of Technology Management, Vol. 15, pp. 31-48.

Besides the abilities to identify new partners and transfer tasks, DMM-technologies provide tools for product-development, evaluate trustworthiness, share knowledge and to learn[427].

Figure 5.1: Value chain structure



Note: Illustration of Porter's value chain from Clarke (1992)[428].

Competitive strategies of firms in textile and clothing industry relate to provisions of the right product at the right time and at the right price. One approach is product-differentiation related to provisions of high-quality, fashionable products that match the fluctuating demands. These provisions may be costly to produce but also enables higher prices and larger profits. Another strategy is cost-leadership including supply-pushed mass-produced standardised items that yield small profit-rates but have higher rates of turnovers. Management of value chains of mass-produced standardised items, relate primarily to cost issues and to logistics i.e. gaining efficiencies in productions and distributions, and exploiting international skill- and cost-differences. Through international outsourcing these value chains can reap the advantages from regional cost differences and skills, but international chain structures are often complicated monitoring-processes with limited feedback-mechanisms, flexibilities, learning and quality levels.

Numerous computerised tools have been developed that supports the supply chain management, production-processes, and automated replenishments, which have special applicability to provision of high-quality products[429&430]. Qualities in textiles and clothing relate both to aspects of objective quality

[427] Spekman, Robert et al (1998): "An empirical investigation into supply chain management: a perspective on partnerships", in Supply Chain Management, Vol. 3, Research paper, pp. 53-67.
[428] Op cit: Clarke (1992).
[429] Holland, Christopher & Ben Light (1999): "Global Enterprise Resource Planning Implementation", in IEEE Proceedings of the 32nd Hawaii International Conference on System Sciences, pp. 1-10.
[430] Holland, Christopher (1995): "Cooperative supply chain management: the impact of interorganisational information systems", in Journal of Strategic Information Systems, Vol. 4, pp. 117-133.

e.g. good materials and high-standard processes, and to subjective quality of fashion, novelty, fitness etc.[431] Provisions of high-quality products relate to timed provisions, of well-manufactured items, that match the actual demands, which call for speedy and flexible production-structures, quick responses, and just-in-time provisions[432]. These provisions are enabled through regional outsourcing, networking amongst skilled businesses and through intensive communication structures[433]. Managerial strains are severe as productions take months or years and as demands develop with seasons or weeks: precise forecasting becomes both critical and impossible. Accurate demand forecasting relies on knowledge on fashion- and market-developments and on speedy, accurate information from sales. Information-processes are essential: retailers inform on market- and fashion-trends to suppliers, assist predictions of future requirements, speedy distribution of key-data to subcontractors as early warnings, and for product developments. Information processes also encompass shared production-knowledge and feedbacks on qualities[434&435].

This chapter contributes with an analysis of the relations between the industrial businesses and the developing ICTs and DMM-technologies. The outline of the industrial information and communication needs is based on the analytical model proposed in chapter two, on the technological traits in chapter three, and the industrial structures identified through interviews, questionnaire and statistical data e.g. presented in chapter four. Emphasis has been put on identification of industrial needs for information, how applied ICTs support them, and how these impact the business relationships and value chain structures. The information needs are related to the different fields of knowledge required in interacting and outsourcing. These knowledge-areas are linked to different stages of contracting and are thought important to the actual organisation of value chains.

In the following sections the value-adding steps, patterns of interaction and applications of ICTs and DMM-technologies are outlined. Firstly the value-adding actions get presented, which direct the structuring of value chains. Increasingly market-segmentations and demand-alterations lead to demand-pull chain structures e.g. individualisations, which compel industry to share information and

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[431] Karnes, Carol et al (1995): "Measuring quality from the consumer's perspective: A methodology and its application", in International Journal of Production Economics, Vol. 39, pp. 215-225.
[432] Perry, Marcia et al (1999): "Quick response supply chain alliances in the Australian textiles, clothing and footwear industry", in International Journal of Production Economics, Vol. 62, pp. 119-132.
[433] Forza, Cipriano & Andrea Vinelli (1997): "Quick response in textile-apparel industry and the support of information technologies", in Integrated Manufacturing Systems, Vol. 8, pp. 125-136.
[434] Gebauer, Judith & Arno Scharl (1999): "Between Flexibility and Automation: An Evaluation of Web Technology from a Business Process Perspective", in Journal of Computer-Mediated Communication, Vol. 5, pp. 1-24.
[435] Burnes, Bernard & Steve New (1996): "Understanding supply chain improvement", in European Journal of Purchasing & Supply Management, Vol. 2, pp. 21-30.

to integrate. Subsequently new models of integration emerge. ICTs and DMM-technologies play crucial roles both in their abilities to distribute information but also in their support for distributed interactivity, which is discussed in the middle section. Interacting DMM-technologies assist new processes of cooperation, product developments, market- and fashion-surveillances, distributed control, presentations of skills and services, and for personalised communication that assist evaluation of trustworthiness. Indeed DMM-technologies impact all stages of contracting and hence impact the industrial structuring, which are discussed in the final section of this chapter.

5.2. Value Chain Structures

Analyses of the Danish and Italian textile and clothing industry show that there exist three major compositions of value chains. One form is based on textiles that are produced directly for other industries e.g. for furniture and automobile. Another is based on textiles produced and delivered for retail shops that redistribute to final consumers. The final and most extensive to the Danish industry is based on provisions of textiles for clothing manufacturers that belabours the fabric and sell their products to retail or directly to final consumers. All three compositions have been subject to internationalisations, technology innovations, individualisations and applications of ICTs and DMM-technologies. Throughout all three value chain compositions there have been receding volumes of mass-produced standardised items and increasing levels of responsiveness to changing demand structures i.e. trends of interactivity in design have become evident: industry cooperates with textile producers on product developments, markets get segmented, final consumers are granted more models and designs to choose from, and processes of individual provisions have appeared. Increasingly the feedback-loops from final consumer to retail, manufacturer and producer get organised and integrated in product developments, which improve forecasting, production flexibility, and quality upgrading.

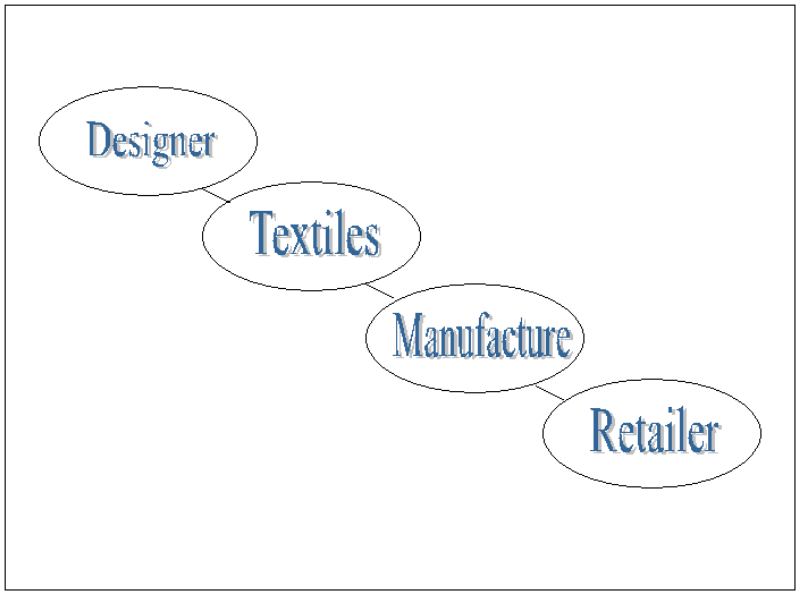
Analyses of value chains highlight the economic gains from separation of tasks, specialisation of business-units and economy of scales. The following section makes an outline of the value chains within the Danish textile and clothing industry, through identification of value-adding steps, production organisations and outsourcing structures. A condition for the structuring of value chains in this industry is the increasing differentiation of markets and diversity in demanded products, which compels the individual businesses and value chains to adapt. Adaptations have included increasing outsourcing levels, smaller production-batches, and processes of individualisation.

Traditional organisation of production respects the pre-set order of material-flows and transformation-steps outlined in chapter 4. Typically, production of textiles is based on a succeeding order of designing, weaving/knitting, colouring/printing, finishing, packing and distribution to retailers, clothing manufacturers or other industries. Clothing is subsequently based on manufacturing processes of designing, colouring/printing, cutting, sewing, finishing, packing, distribution and sales. These stylised value chains only present the most important production steps and in the most common order of events. Technological advances have meant that some of these processes may be performed in other sequences e.g. Benetton has developed low-heated colouring-process that enable later colouring-processes i.e. after sewing without compromising to the fitness of final materials[436]. The following sections offer stylised facts about value chain structures, production modes and industrial outsourcing structures.

Value-adding Steps

Through the manufacturing and service-providing processes the raw materials increasingly get belaboured, which raise the values of products for the consumers; final products represent higher values to consumers than the raw materials. Value chain analyses stipulate the order of operations that enhance the value formation from initial processes to final distribution and usage. Actual formation of value chains depend on the product, applied processes and structures, never the less some stylised facts may be presented.

Figure 5.2: Clothing value chain



[436] Interview result, 2000.

Within the textile and clothing industry there exist three major value chain structures: textile-industry, textile-retail, and textile-clothing-retail. In addition to the mentioned value-adding sectors, there is a wide set of supporting and value-adding aspects such as designing, distribution, storage, and intermediation. First value chain represents the manufacture of textiles directly ordered by other industries that applies cloth in their final products e.g. furniture, carpet production, aerospace, and automobile industry. Frequently there are no or only single links of intermediation, which acts as brokerage-mechanism. Second value chain is the provisions of cloth of private consume i.e. privates' manufacture of own clothing, draping etc. This is the value chain structure with the least turnover, but it is growing rapidly[437]. The final value chain relates to clothing manufacture and distribution for final consume, and is definitely the most complex one: manufacture of some pieces of garment contain well over 100 single production steps[438].

Any production-cycle should start with presentation of a design of the final products, which stipulates the goals for the value-adding steps. Designers are in construction of designs concerned with development of both textiles and clothing that serves the needs of their customers. To a large extent the design-processes are based on subjective ideas and feelings but is also impacted evidently by the requirements stipulated by the production owners. Depending on the position of the designer he or she can develop designs for high-street garment fashion i.e. be trend setting, or provide more standard-quality designs. Besides differences in reputations, skills and earnings of different designers, differences also emancipate in their working structures, where the less skilled or less provocative designers dependent on copying trends introduced by others. Trend-analyses are based on presentation at fashion shows, high-street fashion shops, selected homepages etc.

Despite evident levels of subjectivity in the design-processes, the designers seldom hold sovereignty in developing designs. In construction of clothing the designers have to pay respect to the production-owners' demands concerning market-segments and demands, pricing policy and textile availability. Probably even more restricting are the developments of designs for new textiles, which require good knowledge of production-processes and of the specific requirements by purchasing industries. Design-developments in textiles are on the other hand related directly to the engineering-processes of production innovations and new chemical or mechanical finishing-processes. Hence, designing new

[437] Abernathy, Frederick et al. (1999): "A Stitch in Time", Oxford University Press.
[438] Op cit: Abernathy et al. (1999).

textiles for other industries can be very tiresome and take years before the right product that satisfies buyers' requirements get developed[439].

Textile productions are based on a sequence of chemical or mechanical-processes that gradually transforms the raw materials into finished cloth and adds value to the products. Depending on the nature of the raw materials, the processes include rinsing, spinning, weaving or knitting, and finishing of cloth. Some of these processes are redundant for manufacture of synthetic fibres. Mechanisation and digitisation of production-processes have assisted disintegration of these processes; rinsing and spinning are often integrated activities performed at a single plant, weaving is often performed somewhere else just as knitting is, and the vast number of finishing services as washing, heat treatment, colouring, printing, and product control are often done at separate places by separate business-units[440&441].

Manufacture of clothing is also dissectible into a wide set of separate value-adding steps. Manufacturing-processes deploy the designs and textiles to mark up patterns for cutting, to cut materials, to assemble the cut materials and added accessories, and to finish off the production through the finishing-processes. Maker making and cutting have become highly mechanised and increasingly rely on skilled employees. Assembly on the other hand is largely manual due to inabilities of manufacturing machinery to combine cut materials and perform continuous adjustments. Finishing services include similar processes to those from textile production and services i.e. washing, colouring, printing, product control, ironing, and packing. These processes have also become dissected, performed at separate locations, and in different sequences. A substantial upgrading of production-processes have been accomplished through low-heated colouring that enable colouring of finished garments without any damage to final garment-fitness. This process-innovation have enabled that garment can be made from grey cloth, assembled, and not coloured until specific orders have been received – production cycles have hence been reduced substantially[442&443].

Retail sector also adds substantially to the value chains through collecting and storing the textile and clothing, and subsequently offering a choice to consumers. Retail provides the convenience of product selection and availability at a given location, saving consumers for time and energy in information

[439] Interview result, 1999.
[440] "Competitiveness of the EU Fabrics Industry" (1994), in Textile Outlook International, No. 54, pp. 90-107.
[441] Smith, William & John McCurry (1999): "Industrial Textiles Thrive Through Technology", in Textile World, pp. 1-18.
[442] Interview result at Benetton (1999).
[443] Mantle, Jonathan (1999): "Benetton, the Family, the Business and the Brand", Little, Brown & Company, London.

processing. Retailers contribute further to the value added through providing information and customer services such as product information, washing conditions, availability updates etc.

Production Modes

Value chain organisation depends not only the physical production-processes, but also on the organisational structures of industry, risk takings and the matchmaking institutions. Throughout the value chains there exists a range of matchmaking mechanisms that informs about supply and demand, probably the most renowned institutions are fashion fairs and trade shows where suppliers display their products for the potential customers. In principle the matchmaking is performed between all the value-adding steps, but frequently it is the personal relations and historic events that determine the composition of chains. Another crucial element is the distribution of commercial risks that is divided amongst manufacturers and retailers[444]. Traditional structures of prototyping and fashion presentation at fairs compel retailers to place orders quite early and hence give them the risks. Alternatively, with replenishment structures reduce their risks substantially, and through obtaining individual orders from final customers, they avoid any evident risk-taking at all.

Based on the collected data and performed interviews it has been possible to identify three competing modes of organising the value chains and production-processes within Danish textile and clothing industry[445]. These production modes relate to the distribution of risks, time-to-market and market-structures that the chains are facing for different segments. These modes are termed “programmed”, “perceived” and “unperceived” in the following section, but have many other terms by the individual manufacturer e.g. “standard collection”, and “flash production”.

Table 5.1: Production modes, processes, planning and outsourcing.

	Processes	**Planning**	**Outsourcing**
Programmed	Design-Order-Manufacture	Long-range	Global
Perceived	Design-Manufacture-Order	Medium-range	Europe
Unperceived	Order-Design-Manufacture	Short-range	District

[444] Ebers, Mark (ed.) (1999): “The Formation of Inter-Organizational Networks”, introduction, Oxford University Press, pp. 3-40.
[445] Supported by interview results (1999-2000) and survey (2000).

Programmed modes are probably the most established and planned organisational mode, and applied by all the major producers and manufacturers[446]. This mode is based on planning of collections, market- and trend-analyses, presentations of prototypes at fairs, and receiving of orders before manufacturing. In the programmed mode, retailers place orders at the manufacturers based on expected future demands half a year before the season starts, which may be based on incorrect predictions. Consequently, in the perceived modes it is expected that quantitative errors have been made, which get modified through extra productions or reproduction structures. A total misjudgement of future demands i.e. unperceived demands for new products, lead to entirely new design-processes i.e. unperceived production modes.

Programmed Modes

In the programmed production mode the manufacturing-process starts by trend-analyses and by production of designs. Decision taking, on which clothing-designs to manufacture and sell, depends on a tight communication between designers, textile suppliers and sales representatives, who in combination informs about product possibilities and expectable costs. Through analyses of this information the manufacturing firms decide on which models to pursuit and acquire detailed information on actual production possibilities and costs. Similar structures are evident for development of new textiles, where communication-processes however are more likely to include engineering specialists and a more direct communication with other industries. In order to present the proposed designs and products manufacturers will make physical prototypes and samples that are presented at fashion fairs or mediated through sales representatives.

Fashion fairs and trade shows serve numerous purposes; display of prototypes, show commitments, industrial espionage, personal talks, and communicate sales conditions[447]. These matchmaking institutions hence provide forums for communicating worldviews and trading conditions, which forms the conditions for transacting. Manufacturers will evaluate the volumes of received orders from the fairs and established sales-channels, and decide on production structure and volumes of extra stocking. The entire production cycle from initial trend- and market-analyses, over design-development, prototyping, presentation, order taking, manufacture and distribution often lasts 15-20 months. Hence, summer collections for one year are produced and distributed through the previous spring, winter and autumn, presented at fashion-fairs the autumn and summer the year before, and developed in the spring and winter beforehand. Production cycles for textiles are quite similar, just that the

[446] Interview results (1999-2000).
[447] Inspired by seminal talks with Mario Bonatti (2000).

development-processes may very well last years due to the technical complexity and numerous prototyping needed during the developmental stages.

These organisational structures favour the manufacturers at the expense of the retailers. Manufacturers decide on the forthcoming collections and present their product-ranges to the retailers that are compelled to place orders about half a year before the season starts. Hence, major shares of the risks and financial burdens are placed with the retailers, who have to rely on their superior knowledge of final consumers when placing orders.

Perceived Modes

Programmed production modes are based on yearlong production cycles and on the placing of orders by retailers half a year before actually selling the products, which unavoidably leads to some discrepancy between ordered and finally sold quantities. Discrepancies between retailers' supply and consumers' demand can lead to economically harmful over-stocking, which again mean binding of capital and sales at discounted rates, both reducing the profitability of business. Alternatively, there can emerge under-stocking and forgone sales-opportunities. Being out of stock is equally damaging to business, as some sales are foregone and reputation gets impacted. Nevertheless, some manufacturers and retailers incorporate sell-outs into their high-quality strategies, where being out of stock indicates that their products are popular and of high quality.

Quantitative mismatches are expectable and in the perceived production modes some adjustment-mechanisms are institutionalised i.e. manufacturers make additional stocks or enable reproduction structures. As they are based on known designs the perceived production modes including replenishment programmes have evidently shorter production cycles than for programmed production. Reordering only takes few months depending on the physical distribution of value chains. But, the perceived production mode is also associated with smaller production-batches and higher production costs. This leaves manufacturers with choices of making additional stocks in the initial programmed mode and sell them when replenishment is required, or with only manufacture based on received orders. The first option places risks with the manufacturers but also enables speedy replenishments and additional sales. Second option places the risks with retailers, but this structure implies lost sales-opportunities for both retailer and manufacturer.

Unperceived Modes

Perceived production modes have become a quite important organisational structure that has developed with the increasing segmentation of markets and fluctuations in demand. Perceived modes incorporate responsiveness to alterations in demand situations much more than the programmed modes do. However, the most evident structure for demand-pull structures and individualisation of productions are found in the unperceived production modes. In these situations orders are placed before or concurrently with the designing, before manufacturing commences.

Increasingly the pre-selected range of models chosen by manufacturer and retailer does not satisfy the market-demands. Hence, trend- and market-analyses reveal that other businesses sell different kinds of products to the same market-segments, which calls for immediate product-developments or alterations. Processes of product alterations are based on feedback-mechanisms from retailers or final consumers, and lead to minor modifications of known designs. But, in some situations the fashion- and market-analyses reveal that the provided collections lack a specific component in a collection, or that other manufacturers or retailers make good money from the same market-segment. In these situations there is a clear idea about the needed design, and the retailers can place orders before the final product development and before production. Similar structures are evident for individualised orders as the customer sketches requirements and place an order before production. Unperceived production modes are related to speedy delivery of new items where costs are only a secondary issue to speed. Consequently, production time is quite low, as time-to-market is crucial. Production cycles distributed to firms inside the district, and time-to-market down to eight weeks are frequent.

An emerging trend in the Danish textile and clothing industry is that markets get segregated and demands increasingly become difficult to predict. Programmed production modes dominate the pre-seasonal provisions, but the perceived production modes have become substantial contributors. Programmed modes offer low production costs enabled through international outsourcing and based on long delivery-times. The disadvantages are related to structural rigidities i.e. orders placed half a year before sales, which might lead to catastrophic misjudgements. Perceived modes instead offer shorter production modes but also higher cost-levels associated with smaller batches, switching costs etc[448]. The manufactures instead of the retailers increasingly take the risks. Risks are substantially reduced in the unperceived production mode as productions increasingly are based on direct responses from final consumers, but production costs are generally higher. As yet the unperceived production

[448] Bartezzaghi, Emilio et al. (1997): ”Strategically flexible production and the extra-firm infrastructures: how regions become attractive”, in Integrated Manufacturing Systems, Vol. 8, pp. 333-346.

mode provides only little to the total provision of clothing industry, but is expected to increase dramatically with the increasing needs for individualisation[449].

Outsourcing Structures

Production modes as introduced above get structured on different outsourcing strategies and networking structures as described below. To satisfy the varying demands for low production costs, time-to-market and information feedback-mechanisms, the value chains get structured differently. A general characteristic is that local or district-wise networking entails quick production-processes and intensive information sharing needed for quality improvements, but also induces high production costs. Tradeoffs are evident on all accounts, and the opposite extreme being international outsourcing with long production and distribution times, mediocre communication structures at very low costs in production.

Networking within industrial districts have been the dominating production structures in places like Denmark and Northern Italy. In this networked structure the production gets distributed amongst a wide set of firms that each have specialised in their particular field. Impannatore and other production owners rely on their formal and informal networks to identify the needed business partners for constructing the value chains[450&451]. Districts are characterised by many small and medium sized businesses that each have specialised their productions within a given industry, they operate within a geographically distinct area in which there are unique infrastructures and labour markets, trust is outspoken due to a range of personalised or family relations, and value chains are short-lived based on combinations of cooperation and competition. Individual businesses are subject to the fluctuations from unpredictable markets and are directly exposed to the risks from misjudging demands. Whereas the individual firms prosper or fail, the industrial district itself is very stable and shows remarkable abilities to remain competitive. Individual businesses remain small, which provide them with needed flexibility to employ temporary resources and to respond to failures without large overheads. But, being small impacts the innovative ability of the individual firm; regional cooperation with technological institutions and information agencies allows information on innovative organisations and new technologies to be dissimilated throughout the district. In addition the labourers are carriers of

[449] Interview result, 1999.
[450] Kumar, Kuldeep et al. (1998): "The Merchant of Prato Revisited: toward a third rationality of information systems", in Management Information Systems Quarterly, Vol. 22, pp. 199-226.
[451] Granovetter, Mark (1985): "Economic Action and Social Structure: The Problem of Embeddedness", in American Journal of Sociology, Vol. 91, pp. 481-510.

experiences and new knowledge, which hence get distributed and applied in all the businesses of the district.

Economic gains from regional outsourcing of tasks are mostly related to access to specialised resources, high-quality productions and speedy deliveries. Through intra-district outsourcing the individual business obtains access to specialised skills and resources without compromising the quality of the produced or the timing. Especially the Northern Italian districts have become renown for networking structures enabling high-quality productions. Though highly emphasised[452&453], the economic viability of industrial districts does not rest solely with conventional economic externalities[454]: due to the geographical proximity of businesses within districts it has been possible to generate speedy production-processes and for production owners to establish tight monitoring procedures[455].

Whereas industrial districts hold competitive advantages from speedy provisions, high-quality provisions and flexible outputs increasing wage-levels have partially undermined the competitiveness. With increasing wage-levels throughout Western Europe, the Danish and North Italian industrial districts have experienced accelerating production costs, and receding international competitiveness in lower quality products. Production organisers have been compelled to restructure value chains in order to gain economic advantages from international divisions of labour. Increasingly the labour-intensive functions are placed with businesses outside the industrial districts. For the North Italian districts it has implied that labour-intensive operations have been transferred to the much cheaper Southern Italian districts or in Eastern Europe e.g. Rumania[456]. Likewise, labour-intensive operations in Danish textile and clothing have been located in low-cost countries e.g. Poland and the Baltic countries.

This international or extra-district outsourcing of labour-intensive tasks have meant substantial cost-reductions of value chain operations, but also increasing transportation, managerial, communication

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[452] Corò, Giancarlo & Roberto Grandinetti (1999): ”Evolutionary Patterns of Italian Industrial Districts”, in Human Systems Management, Vol. 18, pp. 117-130.
[453] Zeitlin, Jonathan (1992): ”Industrial districts and local economic regeneration: Overview and comment”, in Frank Pyke & Werner Sengenberger (eds.): “Industrial districts and local economic regeneration”, International Institute for Labour Studies, Geneva, pp. 279-294.
[454] Sabel, Charles (1992): ”Studied trust: Building new forms of cooperation in a volatile economy”, in Frank Pyke & Werner Sengenberger (eds.): “Industrial districts and local economic regeneration”, International Institute for Labour Studies, Geneva, pp. 215-250.
[455] McGovern, Siobhain & Zeine Mottiar (1997): ”Cooperative competition: A Foucauldian perspective”, in DCUBS research papers, Vol. 20, pp. 1-13, available at www.dcu.ie/business/research_papers, February 2000, pp. 1-13.
[456] Grazrani, Giovanni (1998): ”Globalisation of Production in the Textile and Clothing Industries”, BRIE Working Paper, no. 128, available at http://garnet.berkleey.edu/~briewww, November 1999, pp. 1-23.

and monitoring costs. Cost-sawing from outsourcing labour-intensive sewing to low-cost areas are substantial and have more than compensated for the increased logistical burdens and associated costs. Crucial elements of the outsourcing-processes are that the contracted firms can provide the specified services and products at the given conditions; time, quality and prices. Whereas businesses within a district is much easier to monitor and trust-relations are more evident from informal relations and historically developed reputations, choosing a contracting company outside the district generates extra risks for the production organiser, but also larger potential gains. The larger the physical and cultural gaps the more strain there will be on information sharing before contracting e.g. communications of worldviews and agreed monitoring. Consequently, personal meetings consolidate the outsourcing to these areas, and long-lasting partnerships develop.

The third model of outsourcing, besides the district outsourcing and extra-district, international outsourcing of single tasks, is international outsourcing of the entire production-process, however based on Danish designs. Whereas this form of production-organisation is hardly visible in the Italian textile and clothing industry[457] it has become increasingly applied in the Danish case. This extensive outsourcing model where all production-steps get outsourced to a single or a few subcontractors who in turn outsource functions to other subcontractors has become evident. Total outsourcing models have especially been applied in outsourcing to Portugal, where the Portuguese subcontractors, through historical experiences and industrial upgrading have developed their production and managerial skills. Consequently they have taken over an increasing number of production steps e.g. through local outsourcing. Similar structures are also found in the outsourcing to Asian subcontractors, who also possess high managerial skills and access to local subcontractors. Total outsourcing models often require extra time in production due to the extra layer of subcontracting and physical location, but economic gains are substantial due to local skills and very low labour-costs. Development of the individual producers' skills and the upgrading of entire regions have changed the conditions of the outsourcing structures. As the region develops, increasing numbers of tasks are performed locally. Industrial relations are mostly building on the long-term relationship with key-suppliers and additional outsourcing through these key-suppliers to local sub-contractors. Asian industry has developed relatively independently of the Western European manufacturers and hence the long-lasting relationships are less evident between Danish industry and Asian subcontractors: instead the market-mechanisms combined with personal meetings seem to dominate relationship building.

[457] Interview result, Silvano Bertini, Regional Council at Regione Emilia Romagna, Bologna.

Deciding which outsourcing structure to apply is obviously related to the different production modes; programmed, perceived or unperceived. Advantages from outsourcing within the local district are related to access to special qualitative resources, quick deliverances, and high production flexibilities. Notably the speedy deliveries are crucial for initial prototyping and for unperceived production modes, which hence depend on district-based outsourcings. At the opposite extreme, the programmed production modes are much less dependent on short production cycles, as early ordering systems enable long-range planning. Even the extra transportation times and costs pose no serious obstacle. Hence, the programmed production modes will rely extensively on patterns of total outsourcing. Both these outsourcing structures and especially the in-between extra-district outsourcing of single labour-intensive functions get applied in programmed and perceived production modes. Advantages from the single outsourcing model relate to low production costs, a geographical proximity, and good communication structures required for replenishment or reordering programmes[458].

Summary

Summing up on the value-adding processes and outsourcing structures in production, this section has argued for three modes of organising value chains: programmed, perceived and unperceived.

Table 5.2: Production modes and conditions

	Unperceived	**Perceived**	**Programmed**
Quality levels	High	Medium-high	Medium-low
Time-span	Short	Medium	Long
Outsourcing steps	Many functions	Single function	All functions
Outsourcing area	District	Extra-district, Europe	International, Global
Relations	Personalised	Integrative	Integrative with market

The programmed structures are related to supply-push structures through presentations of designed models, and production on orders. Long-range planning enables global outsourcing of all functions. Even though the related transportation-times and costs are evident they are more than offset by lower production costs. Perceived production modes are related to replenishment structures where the businesses can hold extra stocks or engage in reproductions. Holding extra stocks gives better opportunities for quick delivery and sales, but also increase risks from overstocking. Replenishments and reproductions are often time-sensitive, and outsourcing of single or entire processes is located with

[458] Interview result (2000).

other European businesses. Finally, the unperceived production modes are based on entirely unforeseen market-developments, requiring rapid product developments and production-processes, which are ensured through district-wise and European outsourcing.

The three production modes constitute different modes of organising production-processes and business interactions. Speedy and qualitative provisions identified in the unperceived mode get based on personalised relations within the district where orders are received before or concurrently with the designing. Needs for ICTs and DMM-technologies relate to supports for speedy interactions and communications for product modifications etc. In the perceived modes, outsourcing is structured to a single or few subcontractors based on some levels of production integrations. Final designs have been constructed and applied ICTs relate primarily to numerical data e.g. EDI. Third and most conventional mode is based on total outsourcing where developed partnerships with a local supplier form the bridgehead for further localised subcontracting. The time-span is very long and production-processes are based on pre-received orders.

5.3. Models of Knowledge and Interactions

Production of textiles and clothing has undergone important technological alterations that have impacted the organisational structures of value chains. At the organisational level, production steps have increasingly been separated and distributed amongst different sets of enterprises. Organisation of production decreasingly rests with the owners of manufacturing-processes, and increasingly with purchasing industry, retailing companies or with 3rd party-entrepreneurs like the impannatore of the Prato industrial district[459]. At the technological level there has been a widespread digitisation of production technologies that has facilitated separations and internationalisations of tasks[460]. Abilities to transfer tasks internationally open new possibilities for the organiser of value chains, as new processes and suppliers can be identified. New identification-processes will have to pay attention to identifying new partners, ensuring communication structures, quality and monitoring abilities. ICTs and DMM-technologies have been instrumental for new search-mechanisms but also for integrating commercial processes of distributed networks and in enhancing levels of communications.

This section contributes with an outline of information and communication requirements expressed by businesses in the industry[461]. These requirements are leading to fields of knowledge required for

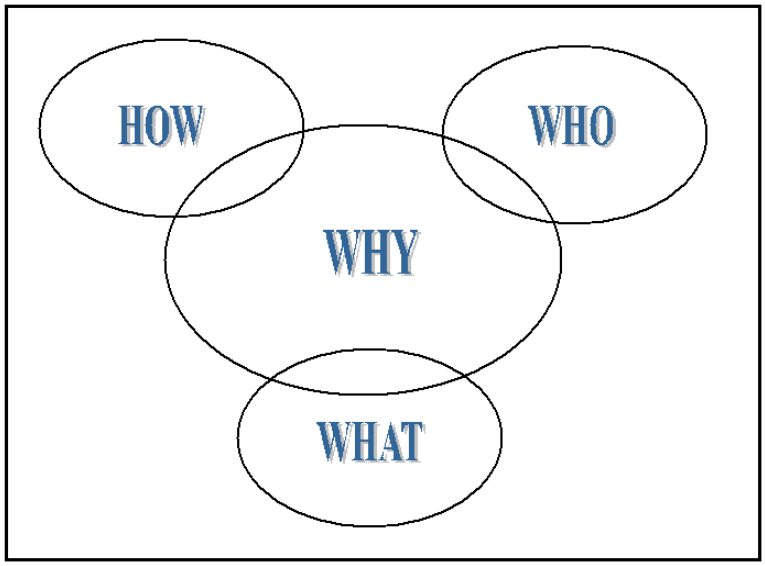
[459] Op cit: Kumar (1998).
[460] Shapiro, Carl & Hal Varian (1999): “Information Rules”, Harvard University Press, introduction, pp. 1-18.
[461] Based on interviews and survey (2000).

economic activities, presented in a model below. Upgrading production skills depend on historic experiences and formation of knowledge is basically communicative phenomenon that directs the information and communication structures of individual businesses and value chains[462&463]. Needs of information and communication are different for various sectors of the industry, which is stipulated below. In a subsequent section, there is an analysis on the impacts from applied ICTs and DMM-technologies on the industrial value chains, production modes, and outsourcing arrangements.

Information and Communication Requirements

Though the production flows presented previously may be viewed as an almost linear process where one value-adding step is followed by the next in a fixed sequence, information-flows are much more complex, transcending the value chains in irregular fashions. Economic decision taking depends on information about and knowing what the market demands, how to provide it and with whom to interact.

Figure 5.3: Fields of Business Knowledge



Inspired by: Lundvall & Johnson (1994).

At a general level the retailers has to acquire information and knowledge on trends, costs, markets, demographics etc. in order to provide the right display of models for their particular market-segments. Manufacturers likewise have to know about emerging trends and market-developments, about costs

[462] Lundvall, Bengt-Åke & Björn Johnson (1994): "The Learning Economy", in Journal of Industry Studies, Vol. 1, pp. 23-42.
[463] Andreau, Rafael & Ciborra Cladio (1995): "Organisational learning and core capabilities development: the role of IT", in Strategic Information Systems, Vol. 5, pp. 111-127.

and prices, about suppliers' capacities and qualities etc. Textile suppliers must know about trends and production-processes too, and like the others about new technologies and innovative businesses. Designers from their particular perspective must have to know about trends, product developments etc.

Businesses have first and foremost to establish why they perform certain tasks, as this impacts the subsequent activities. Through establishing the personal motivations it becomes possible to deal with the commercial activities of exactly what to produce, how to do it and with whom. Information requirements and communication structures vary and depend on the industrial segment, on the provision of products or services, and on the stages of transacting. The different sectors of the industry have different requirements for knowing production technologies, market-developments and fashion-trends, as described below. Likewise, they have different needs when they want to communicate skills and services as compared to presentation of products[464], and the needs also differ in the various stages of transacting: In an explorative stage before contracts get negotiated businesses are concerned with accessing knowledge of potential suppliers, establish their skills and trustworthiness, and to access data from past experiences. In the contractual stages business have to establish exactly what to produce, terms and conditions of deliveries etc. And in the post-contractual stages businesses need to know how they do: whether the quality levels are acceptable, the needs for additional supplies, product alterations and extra information services.

Table 5.3: Knowledge forms in industrial sectors

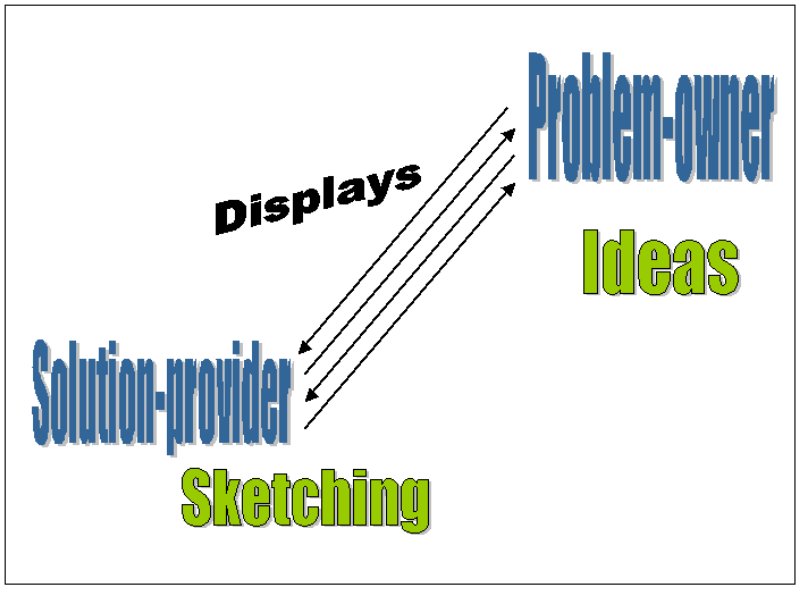
	Know-why	Know-what	Know-how	Know-who
Design	Internal motivation, Styles, Artistic values	Trend- & fashion-analyses, CAD/CAM, Communications	Computers	Skills, Qualities
Textile	Turnovers, Strategies	Trend- & market-analyses, EDI, CAD/CAM, Communications	Production technologies, Computers	Skills, Qualities, Capacities
Clothing	Turnovers, Styles, Strategies	Trend- & market-analyses, EDI, CAD/CAM, Communications	Production technologies, Computers	Skills, Qualities, Capacities
Retail	Styles, Strategies	Trend- & market-analyses, EDI, Communications	Stores, Product presentations, Computers	Skills, Qualities

[464] Op cit: Clarke, Roger (1992).

Knowledge in designing

In the design-processes the individual designer has to establish the personal objectives and guiding strategies. Objectives relate to the subjective motivations and consequently to determination of why the person designs particular products. Personal objectives may be very diverse inspired by economic issues, by artistic values or combinations thereof. This impact on the design-processes i.e. for artistically inclined designers, the presented models will probably be directed towards fashion-creation and trend setting, governed by subjective values. On the other hand, designers dominated by economic motivations probably pay more respect to external requirements expressed directly by customers or by contractors. Information requirements are divergent for these competing design-processes. For the independent designer inspirations are collected from a range of different sources notably from fashion shows, magazines, fashionable shops, sub-cultures etc. Designers that are dictated by economic considerations rely on these sources too, but evidently also on communications with contractors.

Figure 5.4: Communication structures in product developments



Whereas the span of inspirational sources is very wide leading to a vast variety of models, the provision of designs on requests is based on direct communications, which intends to establish one specific design or a specific collection. Frequently the contractor of the design-service have no clear ideas about what is wanted or what is possible to produce, which instead have to be communicated. In order to establish compositions of the requested design the contractor or problem-owner will express some ideas or needs and the designer, as a solution-provider will through analyses of the articulated ideas sketch possible solutions. Through iterative processes the two will eventually establish the exact

requirements and final designs[465]. These design-processes are based on communication structures initiated by articulation of ideas by the problem-owner. Through repetitive product presentations and sketching the design becomes gradually adjusted to fit the wants. Typical procedures for product displays have been based on hand-made sketches and physical prototyping, but increasingly the virtual environments provide alternative and speedier mediations.

One way to enable interactions between solution-providers and problem-owners is to have personal or virtual meetings to establish product requirements. Interactions will, mediated through sketches, gradually lead to developments of final product. Another way of ensuring product developments would be for solution-providers to display a range of opportunities that the problem-owner can choose from. Application of the Internet provides an especially suitable media for interaction, where the problem-owner can navigate through a homepage or virtual catalogue and combine different components for construction of own garments. E.g. Kansas, that offers an online access to limited range of colour combinations[466], or Gap that offers a wide selection of sizes, which surpasses selections in physical outlets[467].

Presentations of skills and possible products are important in establishing whom to work with. In order to gain contracts and sell constructed designs and design-services, designers have to make products and skills known to others, which are possible through various structures e.g. fashion shows, magazines and displays of sketches. Whereas presentations of pre-made designs are relatively simple depending on the chosen media, presentations of skills are more complex. Skills indicate abilities to solve unique problems, and presentation of sketches will only display abilities to solve other problems.

Identifications of business partners both suppliers of physical products and indeed service-providers are complex procedures based on incomplete knowledge and some risk taking. A supplier can display records on production-abilities and past service-solutions, but this only offers partial insight into future abilities. Besides questioning the skills and abilities of the supplier, a business partner or production organiser should also question the intentions of other businesses. Presentations of past results, business profile, technological abilities all contributes to establishing trust and through personalised communication the businesses can exchange their subjective and objective perspectives i.e. worldviews. Communications of worldviews are required for establishing trustworthiness, and

[465] Inspired by Mario Bonatti (2000).
[466] www.kansas.dk (2001).
[467] www.gap.com (2001).

trustworthiness is crucial in ensuring optimal developmental-processes, in predicting partners' actions and as an alternative to perform tight monitoring of processes. Worldviews get communicated e.g. through personal meetings based on subjective and social perspectives, and assisted by historic records, reputations, personalised relations and family ties.

Knowledge in textile productions

As with most other industrial productions, provisions of textile are subject to substantial investments in equipment, which compel production-owners to generate considerable turnovers and finances to match the fixed costs. Secondary concerns for the textile producers are determination of what and how to produce, which are tightly interrelated in the case of textiles. Commercial strategies relate either to production of new types of textiles created through innovative production-processes, innovative materials and additives, or to make known fabrics through cheapest means[468].

Product innovations in textiles are to a large extent based on engineering of new mechanical or chemical processes that enrich the fabrics with new structures, colours, textures etc., which enhance textile quality through novelty of fabrics, increased uniformity in production, enhanced materials resistance and the like[469]. Product developments are based on tight cooperation between designers and specialists in production, and frequently also with the interaction of the purchasing industry notably clothing manufacturers, furniture makers and automobile industry. As with the design-processes, the textile production depends on repetitive sketching and prototyping of materials before the final products are constructed, but these steps are probably more dependent on abilities to sense the physical materials[470]. Alternatively to competing on innovative products, the industry may compete on innovative organisational structures or cheap resources. Managers are concerned with optimisation; optimising production-processes, better production technology, improve output qualities, accessing cheap inputs etc. Irrespective of competitive strategy the producers have to integrate learning-processes and feedback-mechanisms from customers, in order to improve products and processes.

It is also important to establish whom to cooperate with i.e. finding suppliers and reaching markets. Reaching markets and gaining contracts are done through displays of skills, services and developed products at fairs, shows, shops etc., which also provide structures for negotiating contracts and communicating trust and worldviews. Displays of final products can easily be done given the chosen

[468] Op cit: "Competitiveness of the EU Fabrics Industry" (1994).
[469] Cesaratto, Sergio et al (1996): "New Dimensions on Division of Labour: The Case of Italy", in Christian DeBresson (ed.): "Economic Interdependence and Innovative Activity", Edward Elgar, Cheltenham, pp. 120-145.
[470] Interview result (1999).

medium, but exhibitions of skills are more complex. Similar conditions relate for identification of suppliers, which is accomplished through attending fairs and shows, markets research, information brokers etc. Choosing suppliers will be based on features like conditions of trade, availability of skills and resources, established worldviews and trusted relationships.

Knowledge in clothing manufacture

Manufacturers of clothing are granted varying degrees of freedom to choose what kind of apparel to manufacture, which depends on degrees of capital investments, established networks, and acquired skills. Corresponding the choices made by designers, the manufacturers can decide whether they will seek to become trend setting and manufacture fashionable products, or if they will make less fashionable items for larger market-segments. Strategies of manufacturing trend setting clothing is based on supply-push structures and subjected to high risks, but also to large economic gains. Alternatively, the manufacture of medium-quality items is subjected optimised logistics based on integrated feedback-mechanisms with the retail sector, here the economic gains rest with large turnovers and sharing of risks.

Decisions of what to produce are subsequently based on communications with production organisers, designers, textile producers and retailers. Manufacturers are frequently the organisers of production, but increasingly the organisation is placed with other businesses, manufacturers hence only contribute with manufacturing services, production organisers coordinate the processes. Production organisers communicate with designers on the product development, with textile producers and service-providers on the availability of resources and materials, and with retail on the sales performances. Communications with designers are based on establishment of final designs and design-modifications. Knowledge and information from this communication get applied in communication with textile producers and other service-providers. Communication with these sectors is based on what to produce, how, where and when to deliver, which the manufacturer determine through market- and fashion-analyses. Exact information about the quantities and timing of production is however only obtainable through intense communication with the retail link. Retailers inform about present sales, customer feedbacks, and seasonal trends, which are instructive for manufacturers in decisions on production quantities. The exact demand forecasting is based on initial orders, replenishments, market-analyses and the like.

When the exact requirements for what to manufacture and when to deliver have been established the manufacturer must know how to organise production-processes and whom to acquire services and

products from. Timing and quality requirements direct the manufacturer in choosing amongst competing production modes i.e. district networking, single outsourcing or total outsourcing. As for the other sectors, determination of who to work with depends on skills, costs, worldviews, and trustworthiness. Distribution of tasks inside industrial networks depends to a large extent on personal relations, reputation and informal networks. The extra-district international outsourcing is also mediated partly through personal relations as the informal networks can inform about trustworthy and skilled suppliers abroad. But, international outsourcing mostly hinges on intensive market researches, information brokers and personal meetings.

Knowledge in retail

Retailers are very diverse and provide a wide span of products and services at very different prices. In one end of the sector there is the up-market retailers, who offer highly fashionable clothing and individualised services, which enhance values of purchases and consequently the prices. At the other end; factory outlets, grocery stores etc. stock an increasing range of standardised clothing that can be purchased without any sales services and at low costs. And in-between these extremes there are numerous specialised outlets and stores that provide low, medium and high-quality items with divergent levels of services.

Information requirements for the retailers in determining what to sell mostly relate to trend- and market-analyses, and on past experiences. They must be informed about present sales, product availability, market-developments, future trends and innovative sales methods that may impact on their own abilities to compete. In order to provide good clothing-solutions to their customers the retailers must know about customer preferences, new trends and accessibility of products. Whereas the trend-analyses and accessibility of products relate to structured monitoring of fashion trends and communications with suppliers, the retailers possess a unique communication channel with customers through their direct sales. Through discussions of products with customers, surveys and consumer forums they get informed about present and future preferences. Information on consumer preferences is accumulated in the human sales-force and in the accumulated sales data, which is partly communicated to their suppliers.

Substantial contributions to the value-added by retailers are their provision of choices to the customers and provision of feedbacks to suppliers[471]. Many retailing shops are independent units that can make their own decisions on what to display and which prices to ask. Hence, they get concerned with identifying suitable suppliers that offer the right clothing-solutions that match the needs on their market-segments. Identifications of such suppliers are mediated through fairs, shows, sales representatives and the like. However, in order to structure feedback-mechanisms and improve forecasting abilities increasing shares of the retail sector have become integrated with suppliers. Through integrations the suppliers get direct information about sales and fashion-developments, and the retailer gets discounted and prioritised supplies[472].

Knowledge-formation

Information and communication requirements vary with the industrial sector and contribute differently to formation of commercial knowledge. In the pre-contractual phase, before engaging in economic interactions business managers have to establish why they want to perform particular functions and who to interact with. Whereas determination of why they will perform different functions is largely based on internal motivations and financial requirements, the determination of whom to work with is complicated. Identification-processes seek to determine trustworthiness, skills, costs and worldviews of the potential partners, which depends on personalised communications and information about company history, applied technologies, capacities etc. To large degrees personal relations, informal ties and reputations, govern these processes, but information brokerage and other informational services get applied too. Generally, the more complex the requested products and services and/or the more crucial it is to provision of high-quality and timely products, the higher is the vulnerability from mal-performances by others, and the larger the need for trust, shared worldviews, or monitoring and control. On the other side of the coin: the more standardised the item the higher is the competition amongst suppliers, and the less crucial it is with communication and interacting in establishing products and monitor performances.

In the contractual stages the information and communication requirements are different. Production organisers have to establish exactly what to produce and sell, which is accomplished through communications between designers, textile producers, clothing manufacturers and retailers. Through iterative development-processes the exact designs get constructed and thorough market- and sales-

[471] Schmitz, Stefan (2000): "The Effects of Electronic Commerce on the Structure of Intermediation"; in Journal of Computer-Mediated Communication, Vol. 5, pp. 1-22.
[472] Mattila, Heikki (1997): "Expected changes in European garment retailing and their impact on garment and textile production", in Proceedings of World Conference of the Textile Institutes, Vol. 1, pp. 140-149.

analyses contribute to determination of which quantities to provide[473]. Information processes are related to updates on sales data, displays of products, market- and fashion-surveillances etc.

Table 5.4: Contractual stages and knowledge-formation

	Means	**Achievements**	**Knowledge-formation**
Pre-contractual	Personal relations, searches, displayed skills, past experiences	Worldviews & trust	Know-why & Know-who
Contractual	Present ideas, sketch solutions, market- & fashion-analyses	Product-specifications, conditions & reward systems	Know-what
Post-contractual	Monitoring, after-sales services & data	Productions, learning, skills & evaluations	Know-how

In the post-contractual stages communications are related to developing knowledge on how to produce. During the production-processes the businesses will share information about the delivered products and services, and the supplying firms will learn how they do with respect to certain standards[474]. Communications encompass e.g. production techniques where managers exchange organisational knowledge, or specialists exchanging production know-how. The post-contractual communications are hence important for learning-processes and upgrading of skills, but are also important for provision of after-sales services and product information.

Interaction Model

Requirements by different businesses for information and communication abilities depend on their commercial situation and competitive environment[475]. Being in a stable environment with no unforeseen events, businesses would rely much on established routines and only little information sharing is needed e.g. in a programmed production mode. However, in much more changeable environments where new events trigger enhanced uncertainty on competitive situation, in a perceived matter that does not lead to ambivalence and needs for subjective interpretation, a business require large quantities of information to fill in information gaps: in perceived production modes businesses require large volumes of data e.g. EDI-based sales data from EPOS. But conditions may also develop

[473] Interview result (2000).
[474] Rullani Enzo et al (1988): "Networks Between Manufacturing and Demand – Cases from Textile and Clothing Industries", in Cristiano Antonelli (ed.): "New Information Technology and Industrial Change: The Italian Case", Kluwer Academic Publishers, London, pp. 57-95.
[475] Daft, Richard & Robert Lengel (1986): "Organisational Information Requirements, Media Richness and Structural Design", in Management Science, Vol. 32, pp. 554-571.

in entirely unperceived ways that leads to ambivalent situations and needs for subjective analyses and personalised interpretations. In these cases it is also relevant with a good deal of information, but it is more important that decision takers can interact and discuss their subjective interpretation of situations, e.g. as with unperceived production modes and in establishing new business relations. Hence, the more uncertain the situation the large is the need for information, and the more ambivalent the situation the higher is the need for subjective, personal communications e.g. mediated through media rich DMM-technologies.

Needs for enhanced communication levels may also be understood through other perspective e.g. perception of businesses as risk takers and information as a tool to improve knowledge and reduce risks[476&477]. In order to minimise risks from transacting the business should ensure shared worldviews, which induces high levels of trust. Different conditions dictate different levels of risks e.g. ill-definable service-provisions, high product specificity, and small number bargaining increases risks from hold-ups etc. expressed in high transaction costs[478&479]. Purchases of standardised, stock-items are subject to more competition, alternative suppliers and reduced risks. Hence, the higher the product complexity, the more the need for shared worldviews or monitoring, the higher the need for communication.

Finally, in order to learn businesses have to generate feedback-loops, information accesses and enhanced communications[480]. The more distributed and networked the organisational structures the higher the need to share information and communicate with other businesses, which generate knowledge about own performances and sales of products. The higher the need for high-quality provisions, the higher the need to get speedy and accurate feedbacks. In addition, communications are needed in order to make product developments, which in a world of incomplete knowledge can only be obtained through discussions between problem-owners and solution-providers[481].

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[476] Knight, frank (1986): "Risk, Uncertainty and Profits", in Louis Putterman (ed.): "The Economic Nature of the Firm", Cambridge University Press, pp. 61-65.
[477] Babe, Robert (1995): "Communication and the Transformation of Economics", Westview Press, Oxford.
[478] Williamson, Oliver (1975): "Markets and Hierarchies: Analysis and Antitrust Implications", Collier Macmillan Publishers, London.
[479] Holmström, Bengt & John Robert (1998): "The Boundaries of the Firm Revisited", in Journal of Economic Perspective, Vol. 12, pp. 73-94.
[480] Lundvall, Bengt-Åke (ed.) (1995):"National Systems of Innovation – Towards a Theory of Innovation and Interactive Learning", Pinter, London, Introduction, pp. 1-19.
[481] Inspired by Mario Bonatti (2000).

Stylised processes of design, textile, clothing and retail stipulated previously present core elements of industrial value formations in textile and clothing. Increasing values get manifested in the belaboured materials that represent increasing values in use for final consumers. Single-file value-additions in the value chain structures have been especially evident for production of standardised products for a uniform demand-driven market, which were the profile of much Western European textile and clothing in the 1970s and 1980s. In the 1990s income-levels have risen and customer preferences have become much more differentiated, which have divided markets into minor segments. Instead of relying on mass-produced provisions the industry has been compelled to respond more to demands, offer increasing product varieties, target smaller segments, and indeed trends of individualised requirements and provisions have increasingly become apparent[482&483]. Due to differentiated and fluctuating demands value chains get more exposed to mismatches between the provided items and services, and actual demand situations.

Tools for the industry to match the increasing requirements of small lots and larger varieties have been related to improved demand forecasting and impacting customer preferences through advertising and branding. Improved forecasting has been enabled through accessing and analysing sales data, historic events, customer information etc. e.g. provided through EDI-based information from access from EPOS, retail, and service providers. A dual strategy of predicting and impacting demands has been accomplished by continuous acquisitions of market-information and by advertising and branding products. Advertising impacts the customers' needs and branding impacts their perception of the product quality. Both aspects have become widely applied, and accelerating with the increasing purchasing powers of all market-segments and upgrading of value chains[484&485].

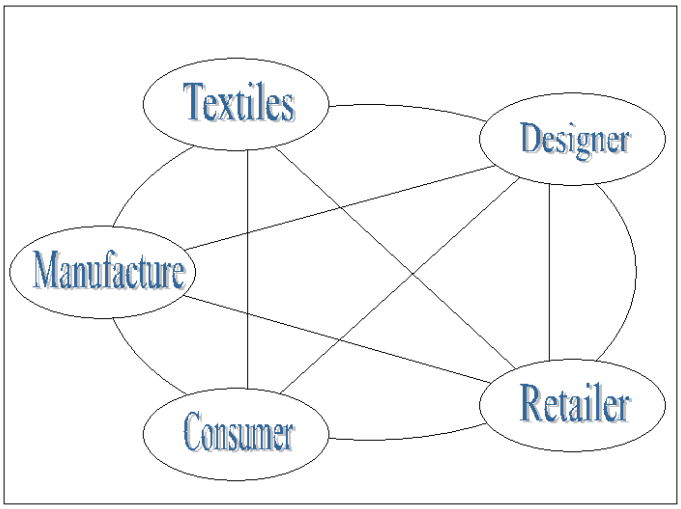
Strategies of increased branding and product differentiations have enhanced quality-levels, but the viability of value chains still dependent on provision of quality products at sensible costs, and on knowledge on relevant market-segments. Viability of value chain operations rests not exclusively with cost-efficient provisions, but equally with matching the quality requirements by customers, e.g. more fashionable products or better objective qualities. Ever-speedier market-alterations have compelled value chains to emphasise information and knowledge sharing, on providing cheaper products and

[482] Byrne, Chris (2000): "The Industrial and Social Impact of New Technology in the Clothing Industry into the 2000s", available at www.davidrigbyassociates.com/articles, February 2000, pp. 1-21.
[483] www.just-style.com (2001).
[484] Gereffi, Gary (1999): "International trade and industrial upgrading in the apparel commodity chain", in Journal of International Economics, Vol. 48, pp. 37-70.
[485] Campbell, Alexandra (1998): "Cooperation in international value chains: comparing an exporter's supplier versus customer relationships", in Journal of Business & Industrial Marketing, Vol. 13, pp. 22-39.

increased product-flexibility. Attempts to match the fluctuating and differentiated demands encompass a wide range of technological and organisational alterations related to aspects like: enhanced information diffusion to generate early warning systems, speedier production cycles to enhance responsiveness and flexibility, just-in-time structures to limit production and storage costs, new production technologies to support smaller production batches, and innovative processes and materials to enhance product qualities.

Altered organisational and technological structures have also impacted the composition of the traditional value chain structures. Instead of perceiving value chains in the conventional linear ways as a sequence of value-adding processes performed downstream, the information and knowledge sharing mechanisms indicate much more complex structures. Production-processes still add values to belaboured material, but values are not given entirely by the embodied production-processes, as the customers' subjective perceptions and preferences have become essential and instrumental in the transformation-processes. Value chains transform materials downstream but transfer information both down- and upstream and communications between all sectors are essential for generating the required shared knowledge. Production-processes and value-adding steps increasingly rely on initial inputs on customer preferences, either by customers themselves or via information from retailers. Determination of what is actually wanted by customers and market-segments, possible to produce, and at what costs depend on inputs from textile producers, manufacturers and designers combined. Though it is possible to place responsibilities in production and ownership of processes the value chain viability hinges on mutual interests and shared communications and knowledge-formation. Value chains no longer merely presents the one-way production structures but increasingly upstream information dissimilation and networked knowledge-formation.

Figure 5.5: Interactive communication structures



Especially the growing requirements for individualised and customised provisions require enhanced communication structures between consumer and providing industry[486]. Consumers have to communicate product requirements with the suppliers, which in turn have to embrace the provisions from entire value chains. Individualisations and customisations are most frequently based on consumers' contact with retailers, as they possess the structures for direct communications and professional services. The customisation-requirements get communicated to manufacturers, designers and textile suppliers that in combination develop and produce the specified items. Provision of individualised items hence hinge on extensive communication structures that encompass entire value chains at entirely new levels than e.g. the EDI-based information sharing in single-file mass-producing value chains.

Industrial restructuring

As a consequence of the economic developments and increasing differentiation of demands[487], the industrial structures have become transformed from the late 1980s until now and is expected to evolve even further[488&489]. Industrial organisations prior to the mid-1980s emphasised the role of manufacturers and other production-owners, who possessed a unique product and market-knowledge and special resources for predicting future demands. Large-scale manufacturers possessed more information and knowledge about the uniform mass-markets, than any individual retailer did. The special knowledge about customers and markets were generated through extensive sales data,

[486] www.just-style.com (2001).
[487] Outlined in chapter 4.
[488] Rigby, David (1992): "Textile Supply Chain Management: New Problems, New Solutions", at www.davidrigbyassociates.com/articles, available February 2000, pp. 1-9.
[489] Op cit: Byrne (2000).

networks of sales representatives and specialised personally embodied knowledge. Industrial structures hence facilitated construction of large-scale manufacturers that embraced all relevant knowledge and most production steps.

Supply-push market-structures of the 1970s and 80s that favoured these large manufacturers gradually changed; markets became segregated into minor segments, which required introduction of demand-pull communication structures and restructuring of value chains. Locations of knowledge centres have consequently shifted from the big manufacturers that had large volumes of data and the required human resources, towards retailers who have the most direct access to the final consumers and the numerous market-segments. Due to the direct market-access retailers are in a special position to acquire knowledge about the consumer-tastes and the future development of demands. Access to information and knowledge about market-segments has become increasingly important, which have inspired the retail sector to centralise in order to pool resources and improve market-knowledge. Market-differentiations and changed production and communication technologies have also been instrumental in altering production structures towards small batches. Sizes of manufacturing companies have diminished accordingly, partly facilitated through increasing outsourcing of sales and production steps.

Value chains have through the past decades with major transitions in demand structures continuously shifted profiles and tasks have been distributed differently. One apparent shift in chain structures has been a shifting position of sales and sales representatives. Traditionally, the sales function has been located with the retailing sector, but the increasing importance of a direct access to final consumers and knowledge about markets have called for altered structures; manufacturers have introduced fabric-outlets and own or franchised shops, own online sales, and EPOS and EDI-based information sharing structures with retailers, and even insourcing of sales from retail-companies to vendors have become introduced. Growing levels of interaction between manufacturers and retailers have improved competitive situation of entire value chains, e.g. vendor-managed inventory have advantages for the retailers that save resources and finances in stocking and promotion, and the manufacturers gain by obtaining direct information on consumers[490&491]. Similar relations have also been evident for the b2b sales, where textile producers and clothing manufacturers outsource sales-functions e.g. to specialised

[490] Damsgaard, Jan (1996): "The Diffusion of Electronic Data Interchange", doctoral thesis, Aarhus University, Denmark.
[491] Op cit: Schmitz (2000).

agencies or warehousing and distribution providers that are closer to the market, possess special knowledge, storage capacities and infrastructures[492].

Summary

In this section it has been revealed that emerging ICTs and DMM-technologies hold some potential for industrial restructuring, which increasingly are required due to altered demands. Changes in the market-demands compel substantial parts of industry to integrate the wishes and needs by individual consumers and small segments. Correct demand forecasting and adequate production flexibility can only be ensured through intensive communication structures including all sectors of the value chain.

Interactions and communications are increasingly required and facilitated by electronic technologies. Needs to interact relate to developments of products and designs where the designers have to communicate with manufacturers, textile producers, and retailers, and progressively more directly with customers. Interactions also facilitate shared knowledge about market-demands, where retailers and suppliers exchange information on sales, production progress and availabilities, which in addition enhance the forecasting abilities and learning-processes. Final focus of the interactivity relate to matchmaking, and to establishments of shared worldviews and monitoring. Brokerage functions enable identification of new business partners, but accessing online information about the firm history, provided skills, products and services indicates the appropriateness of businesses. Establishments of shared worldviews are needed to ensure trustworthiness and the correct intentions of partners; alternatively interactions are required for monitoring.

Multimedia tolls provided the required personal and media rich communication-opportunities. DMM-technologies enrich communications with abilities to present products, to monitor processes, to hold virtual meetings etc., which assist the operations of value chains. These communication structures are instrumental in exchanging personal perceptions and subjective analyses reducing the uncertainty in operating in volatile environments. Communications also enable shared knowledge about fashion- and market-developments, through which better demand forecasts are enabled reducing economic risks. And finally, monitoring and virtual meeting amongst managers and specialists assist the feedback and learning-processes.

[492] Interview result (1999).

Applied ICTs and DMM-technologies impact the various operations differently. In the pre-contractual stages knowledge on why and who get supported by the information brokerage and the improved abilities to display skills and to communicate worldviews. In the contractual stages applied ICTs assist knowledge-formation of what to produce i.e. virtual presentations, shared workspaces for product developments and subsequently by barcoding and EDI-messaging. Finally, the post-contractual stages get assisted through support of know-how issues: feedbacks are received, web-based monitoring and meetings etc. through which the businesses learn and upgrade their skills.

5.4. Impacts from DMM-Technologies

Introductions of ICTs and DMM-technologies to the Danish textile and clothing industry have assisted formation of new levels of interactions and industrial reorganisation. Some of the most widely emphasised attributes from applying digitised communications are abilities to transmit data between distributed nodes at low costs and the little time needed in transmissions[493&494]. The enhanced abilities to become connected in a shared information society impact the ways we perceive the surrounding world, ourselves, and consequently how we interact[495&496]. Abilities from digitised communications have vast commercial potential as information handling and service-provisions may be separated from the physical production-processes, introductions of new and better products, and to speedier processes[497&498]. Introductions of electronic communication structures have improved businesses abilities to reach new markets and find new partners; electronic markets have been facilitated through improved browsing and information sharing abilities[499]. However, the information sharing abilities also improve the interaction in established relations pushing developments towards electronic hierarchies[500].

This section offers an outline of the impacts from applied ICTs and DMM-technologies in the textile and clothing industry. Applied communication technologies hold potential to enhance commercial interactivities, improve formation of new links and tasks, and for restructuring value chains. A more

[493] Negroponte, Nicholas (1995): “Being Digital”, Hodder & Stoughton, London.
[494] Kelly, Kevin (1999): “New Rules for the New Economy”, Penguin Books, New York.
[495] Galbriath, John (1971): “The New Industrial State”, Penguin Books, London.
[496] Castells, Manuel (1998): “The Rise of the Network Society”, Blackwell Publishers, Oxford.
[497] Varian, Hal (1998): “Markets for Information Good”, working paper, pp. 1-19.
[498] Atkinson, Robert & Randolph Court (1998): ”The New Economy Index”, available at www.ppionline.org, November 1998, pp. 1-50.
[499] Malone, Thomas et al (1987): ”Electronic Markets and Electronic Hierarchies”, in Communications of the ACM, Vol. 30, pp. 484-497.
[500] Johnston, Russell & Michael Vitale (1988): “Creating Competitive Advantage With Interorganizational Information Systems”, in MIS Quarterly, Vol. 12, pp. 153-165.

detailed impression is offered below, whereas discussions of theoretical contributions and consequences are presented in the next chapter.

Functions and Processes

ICTs and DMM-technologies have major impacts on the information sharing and knowledge-formation for all the value-adding tasks: designing, textile production, clothing manufacture and retailing. Use of digitised information sharing is related to easy transmission capabilities of the commercial data. Sharing of data within organisations and value chains enable higher levels of interactivity, shared work and knowledge-formation. Dissimilation of data speeds up interactivity and work-processes enabling quick responses[501&502], and new monitoring tools enrich management and project planning[503].

Information sharing through data transmissions in support for commercial activities has related to EDI-messaging but also e-mailing and shared access to files and databases have evident commercial impacts. With development of multimedia structures and distributed interactivity the DMM-technologies have become applicable for even more commercial activities: shared workspaces, product developments, communication of worldviews etc. Upgrading of transmission abilities and computing powers have improved applicability of distributed multimedia e.g. enabling more realistic presentations of computerised fabrics and designs, for virtual catalogues, for interactivity as videoconferencing and shared workspaces.

Design

Design-processes add value by defining the goals for the manufacturing-processes. These information services have increasingly become digitised through application of computers in the design-processes and hence become physically separated from the production-processes. CAD-technologies are mostly DMM-based including virtual presentations and virtual catalogues, 3D-moddeling, scanned materials, models and fabrics databases etc. The impacts from applying these tools in design-processes relate to a wide span of processes: Virtual presentations and transmissions of semi-finished fabrics and models that can be exchanged with contractors for feedback and further product developments. Virtual presentations of final designs are applicable for Internet-based worldwide market-reach through which

[501] Forza, Cipriano & Andrea Vinelli (1996): "An analytical scheme for the change of the apparel design process towards quick response", in International Journal of Clothing Science and Technology, Vol. 8, pp. 28-43.
[502] Kokuryo, Jiro (1994): "The impact of EDI-based quick response systems on logistic systems", in Gerad Pogorel: "Global Telecommunications Strategies and Technological Change", North-Holland, Amsterdam.
[503] Riganti, Laura (1999): "Progetto di sviluppo di Extranet", unpublished working paper, Studio San Salvador, Telecom Italia, Venice, Italy.

timely and costly physical prototyping become superfluous. Impacts also include creation of and speedy distribution of models for belabouring by CAM-technologies e.g. weaving, printing and cutting. And shared access to stored data on known models and fabrics for speedier manipulations. In addition, the accessibility to the Internet enables new modes of market-reach, service provisions and fashion- and market-analyses. Improved market-reach includes accesses to entirely new geographical markets and other market-segments, as well as new feedback-mechanisms where the customer can deliver feedbacks for customised product developments.

Textile

Productions of textiles are also assisted evidently by applied ICTs and DMM-technologies. Through CAD/CAM-files the digitised designs are transferable through electronic networks and directly imposed in the production-processes e.g. weaving, and printing. The production-process is also entangled in extra information as the individual steps can be monitored electronically, data on material flows and production-quality are generated, and data provides inputs for speedier operations. Lean production techniques reap the benefits from digitised monitoring of materials and processes in continuous readjustments of the mechanised processes[504]. Computerisation of production-processes implies speedier operations, reduced wastes, and improved qualities. Quality improvements relate partly to better production technologies and partly to enhanced feedback-mechanisms with the contracting firm[505]. Important to enhancing levels of quality is also virtual presentations of products for online control and videoconferencing for management assistance. Besides the improved structures of interactivity, applied ICTs also enhance market-access and surveillance through improved browsing, marketing, market- and technology-analyses etc.

Clothing

Applications of ICTs and DMM-technologies have been especially evident in the manufacture of clothing. Advantages are numerous relating to improved production-processes, enhanced interactivity with suppliers and designers, speedy sales data from retail, and to enhanced market-reach. Production-processes are improved evidently through shared CAD/CAM-files that integrate the product-development-processes with designers, and as the manufacturing-processes increasingly get automated[506]. One of the most evident improvements from digitised production-processes relate to computerisation of marker makers and cutting-processes that have become possibly to automate

[504] Op cit: Abernathy, Frederick et al. (1999).
[505] Bilalis, Nicholas et al. (1999): "Technical and qualitative information sharing between fabric finishing and garment manufacturing", in Computers in Industry, Vol. 38, pp. 201-206.
[506] Interview result (2000).

entirely. The improved information sharing systems with retailers include EDI-based communications that informs about sales progress and stocks, which provide early warnings for manufacturers as well as an opportunity to introduce automated replenishments, vendor managed inventory, and up-stream production integration with sub-suppliers. Combined these tolls also facilitate better forecasting programmes, speedier provision-processes, and mass-customisation strategies[507]. As with the other sectors the Internet-based information access enables renew market-accesses e.g. online sales, access to specialised services e.g. technology-, market- and fashion-analyses as well as online control.

Retail

Digitised communication-processes have also had evident impacts on the retailing sector through improved communication-processes upstream, new market-reaches, and abilities for providing improved services to customers e.g. delivery updates and customisations[508]. Through the direct communications with final customers the retailers hold a unique access to information and knowledge about customer preferences, which can be transmitted throughout the value chains. One evident information aspect relates to the quantities of sold items and needs for replenishments mediated through EDI-based communications, another is related to product developments, where retailers inform on new needs, alterations and customisation requirements. EDI-messaging has been particularly important in constructing just-in-time deliverances and for mass-customisations. Information processing through the Internet has especially evident implications to the retailers, due to the customers increased accesses to new outlets and competitor information. Brick-and-click and virtual companies increasingly offers online sales-opportunities coupled with virtual try-on, consequently established retailers experience increasing competitions. An emerging trend is the development of showrooms, where shops displays increasing ranges of designs but stock ever-fewer items[509]. Sales become dependent on precise and reliable replenishments and on communication of individual customer specifications for individual procurements. However, a major obstacle for the success of pure showrooms that only holds a single item that can be tried on for fitness and colour is the required time in productions from initial order to final provision and distribution, which the customers find inconvenient.

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[507] Holland, Christopher & Geoff Lockett (1994): "Strategic Choice and Inter-Organisational Information Systems", IEEE Proceedings of the 27th Hawaii International Conference on System Sciences, pp. 405-413.
[508] Christensen, Clayton & Richard Tedlow (2000): "Patterns of disruption in retailing", in Harvard Business Review, Vol. 78, pp. 42-45.
[509] www.just-style.com (2001).

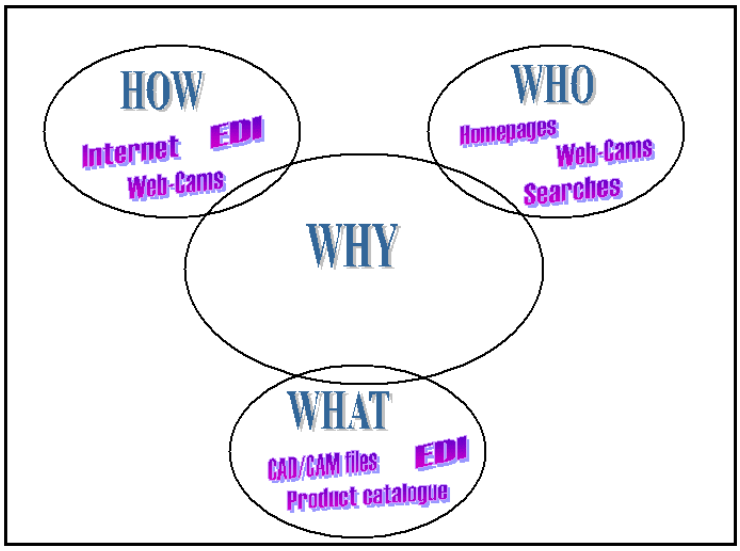
Knowledge-Formations

This section relates the information and communication technologies to the processes of knowledge-formations i.e. know-why, know-how, know-what and know-who. Knowledge on why a business chooses to perform certain tasks remains an issue of past experiences, personal motivations and individual objectives and, as such the electronic communications do not contribute to knowledge-formations. Nevertheless, enhanced communications and feedback-mechanisms will gradually lead to improved skills and production abilities e.g. upgrading of products from low-to-medium quality to medium-to-high qualities[510&511]. Though improved skills do not alter the abilities to determine the know-why issues, the conditions may change as the options increase. Individuals and businesses gradually learn and develop opportunities to make up-street fashions. Likewise, the combined processes of enhanced communication, integration of digitised technologies and less costly production technologies have; altered the financial requirements and strains on productions, the needs for turnovers, and reduces switching costs. This leaves the individual business with more commercial options that can result in changed commercial strategies and activities.

ICTs have direct impact on establishing what to produce. A substantial element of value chain integration relate to the lean processes facilitated through EDI-messaging. Codifying final products and components, barcoding and scanning enable that materials can be located anywhere in the production-process and in intermediate and final stocks. EDI-based information sharing smoothens value chain interactions but requires that business partners are identified, products can be codified, and that businesses share similar EDI-processes[512]. DMM-technologies contribute to establishments of what to produce through other means: shared workspaces, virtual product displays and videoconferencing enhance the communications within value chains and assists speedier product developments. Product-developments are mediated through virtual presentations of semi-finished designs, and the final designs are presented through virtual product catalogues. Shared workspaces provide distributed opportunities to manipulate the same items applicable for product developments and alterations, but virtual meetings are also assisting through shared fashion- and market-analyses, demand-forecasting, discussing features, explaining processes and monitor developments.

[510] Krause, Daniel & Lisa Ellram (1997): ”Critical elements of supplier development”, in European Journal of Purchasing & Supply Management, Vol. 3, pp. 21-31.
[511] Op cit.: Gary Gereffi (1999).
[512] Brousseau, Eric (1994): “EDI and inter-firm relationships: towards a standardization of coordination processes?”, in Information Economics and Policy, Vol. 6, pp. 319-347.

Figure 5.6: DMM-technologies and knowledge-formation



Knowing who to cooperate with depends on information access on potential buyers and suppliers, evaluation of their skills, performances and trustworthiness etc., which is partly mediated through personal and informal networks, but increasingly information services improve the brokerage facilities[513]. Establishing who to work with is assisted by ICTs and DMM-technologies as these tools assist the pre-contractual orientation phase, the contractual processes and the post-contractual steps. Identifications of potential partners are assisted as decision takers and information providers navigate the extensive volumes of homepages for product skills, business performances, product attributes etc. Internet navigation is complicated by only limited overviews but assisted by specialist information brokers, electronic marketplaces, and generic searches where businesses and products can be identified through key terms and product codes. An emerging feature of the electronic matchmaking is the XML-standards for describing and presenting products.

In the contractual phases the decision maker is assisted by homepages displaying business history, services and products e.g. by photo-realistic 3D-modelling virtual presentations[514], which evidently improve the evaluation of product attributes and business skills. Establishments of personal relations are still essential for interacting with new partners as these supports communication of social and subjective perspectives, sharing worldviews and established trust[515&516]. Media-rich communications

[513] Kanet, John et al (1999): ”Application of information technology to a virtual enterprise broker”, in International Journal of Productin Economics, Vol. 62, pp. 23-32.
[514] Gray, Stephen (1998). “Virtual reality in Virtual Fashion”, available at www.institute.ieee.org/select/0298/vr.html, April 2000, pp. 1-10.
[515] Op cit: Granovetter (1985).
[516] Kraut, Robert al (1998): ”Coordination and Virtualization: The Role of Electronic Networks and Personal Relationships”, in Journal of Computer-Mediated Communication, Vol. 3, pp. 1-34.

e.g. face-to-face or virtual meetings enable intensive information sharing required for expression of subjective perceptions[517]. Market-volatility, product-developments, technological innovations and formation of new business relations are all situations of big uncertainty and ambiguity, which calls for media-rich communications. Communications of social, objective and subjective spheres contribute to establishment of shared worldviews, making product-specifications explicit, developing products, monitoring structures, responsibility and reward structures. Post-contractual stages including feedback-mechanisms, learning and service provisions all get assisted through electronic networks and applied ICTs and DMM-technologies, just as the transactions in electronic commerce get assisted.

Finally, these communication tools also assist the formation of know-how. On one hand, information services and brokers may contribute with information on latest production technologies and innovative organisational structures. On the other hand, enhanced communication with managers and specialists from partnering companies provides the business with feedback-mechanisms for upgrading productions and required information to learn. Establishment of know-how does not only relate to how the individual business operates or how the individual tasks are provided, but equally to the distribution of tasks amongst businesses in value chains. Knowing how to organise value chains encompasses information about competitive advantages of different partners, strategic positioning, and the allocation of tasks accordingly. Hence, functions become outsourced to established partners e.g. sourcing of sales from Magasin to manufacturers[518], or outsourcing IT-operations and functions to technology vendors[519]. Or new specialist providers are included e.g. new sewing businesses in the Baltic countries, or specialist online fashion- and market-analysts.

Summary

Applications of ICTs and DMM-technologies have evident impacts on the investigated textile and clothing industry. Design-services increasingly get supported by CAD-technologies, which facilitate higher levels of interactivity with other sectors and costumers, and for enhanced levels of outsourcing possibilities. Increasingly the CAD-programmes have become compatible with CAM-technologies integrating the manufacturing operations with designing, and improving abilities to customise provisions. Clothing manufacturers are equally assisted by sharing CAD/CAM-files but also by monitoring- and control-mechanisms at distributed subcontractors. Retailers gain enhanced abilities to communicate with customers and for sharing knowledge with vendors.

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[517] Op cit.: Daft & Lengel (1986).
[518] www.magasin.dk (2001).
[519] Outsourcing of computer capacities by Gerber in support for distributed marker making, www.gerbertechnology.com (2001).

Besides assisting the value-adding processes, the ICTs and DMM-technologies are also assisting production organisers and decision takers in establishing knowledge on what, how and who. What to produce is determined through communication-processes through all industrial segments, where the product developments are generated through shared workspaces and virtual catalogues, EDI-messaging informs about production quantities. Who to work with is mediated through brokerage functions, analysing provided products and skills, and through personalised meetings that establish shared worldviews and trust levels. Knowledge on how to produce is mediated as information about products, processes and technologies are shared, as managers and specialists can exchange information enhancing product qualities, and redistributing tasks amongst businesses in order to enhance value chain viability.

5.5. Conclusions

This chapter contribute with an outline of value chain structures in the Danish textile and clothing industry based on the four processes of designing, textile production, clothing manufacture, and retail. Throughout the chapter it has been suggested that combined developments in market-demands, production-technologies and ICTs have been driving developments from supply-pushed structures towards demand-pull markets for textile and clothing. Analyses of this structural restructuring have been enabled trough outlining the value-adding processes and the organisation of industrial value chains. Increasingly these chains are facilitated by applied ICTs and incorporate communication-structures that encompass all the businesses.

Two competing strategies prevail in the industry i.e. product differentiations and cost-leaderships. Being a cost-leader is associated with provision of mass-produced standardised items, where production costs are reduced through global outsourcing and purchases at cheap suppliers. Provisions of these goods are mostly associated with long-range programmed production modes, as time is required for the extensive transportations. Diversified products are enriched with objective qualities and subjective qualities of novelty and fashion. High-quality, fashionable products are produced through small-batch processes in district-based or European outsourcing structures, which provide the required combinations of quality and flexibility for just-in-time provisions. Supply of quality-based items depends evidently on accurate demand forecasting, speedy provisions and high production flexibility associated with perceived and unperceived production modes. These accomplishments can only be reached through high levels of communication and interactivity amongst the business partners.

Increasingly the DMM-technologies open up for distributed communications and production integrations, which facilitate enhanced levels of international outsourcing. Designing has become largely reliant on computerised technologies, and distributed files in product development transmittable through the Internet. Through outsourcing of production and manufacturing-processes, and through enhanced communication and monitoring abilities the international cost-driven value chains can learn and upgrade. Besides the increasing abilities to learn and to upgrade processes for provision of medium-to-high quality products, the business partners may also improve levels of interaction e.g. making product alterations and sharing sales and production data, which makes the international outsourcing relevant for the perceived production modes too.

Crucial to the viability of value chains providing the Western European markets with high-quality products are shared knowledge of what to produce, which is established through fashion- and market-analyses, shared information and consumer interactions. Retailers and specialised information providers hold unique insight to the fashion- and market-developments, of emerging demands and personalised requirements, which can be communicated to other segments of the value chain. In these demand-driven markets the key to success is the access to consumers, which has driven industrial segments to apply new strategies: retailers increasingly apply personalised services and binding structures i.e. personalised marketing, provisions, discounts and services. Manufacturers increasingly provide online sales, factory outlets and merge with retailers. And value chains increasingly apply tools for personalised provisions e.g. mass-customised structures and online abilities to personalise colours and sizes for fitness.

Knowledge-formation is also crucial in the fields of why, how and who. Determinations of why a business chooses to supply particular products and services are primarily a question of personal motivations, but the actual choices of businesses are impacted by their historic developments, learning processes and accumulated skills. ICTs may be applicable in upgrading skills and enhance the set of strategic choices: lower costs of production technologies and smaller production lots reduce the financial requirements and enable strategies based on more artistic values and internalistic motivations to dominate. How to produce is likewise the outcome of historical processes, but also dictated by product and technological innovations, by organisational changes, by applied ICTs. In addition to the firm-specific developments, the distributions of tasks within value chains depend on economic efficiencies and strategic positioning. Determination of who to partner with is also important to the viability of value chains. Identification of potential suppliers increasingly get supported by online

information brokerage and matchmaking services, but to a large extent remain based on shared worldviews and trustworthiness established through personalised relations. The more difficult it is to present and visualise actual products and services the more complicated it is to specify contracts and the more a shared worldview is needed. Alternatively, the more it will be required with monitoring and post-production control systems.

ICTs and notably DMM-technologies increasingly provide the opportunities for electronic communications, distributed interactions and sharing of complex information and knowledge. One string of the technological development is expressed in the support for interactivity in product developments: CAD/CAM-technologies increasingly get compatible through Internet-based interfaces, which enable worldwide distribution of tasks. Importantly, the interactivity is expressed in shared product developments mediated through virtual product presentations and shared workspaces. The shared development-processes are either based on problem-owners requirements and solution-providers sketched ideas, or the developers' presentations of skills and semi-finished products, which the customer can choose and pick from and combine for personalised requirements.

Second string of electronic communications is connected to enhance responses and shared production information between businesses. ICTs support the structures of lean production, production on orders and just-in-time provisions, based on EDI-sed information transcending both up- and downstream the value chains. However, the enhanced communication abilities from multimedia technologies also provide means to share information and analyses of market- and fashion-developments e.g. videoconferencing, homepages and virtual catalogues in assistance in exchanging visions of fashions and markets. Retailers inform on fluctuations in demands and required product alterations, textile producers and manufacturers do likewise on product availabilities and possibilities. This information is shared with designers who are knowledgeable on production techniques, trends and fashions. Enhanced levels of feedback-mechanisms not only improve the demand-forecasting processes but also assist the firms in learning and improve products and services.

Third contribution from enhanced communication abilities hinge on the personalised communication abilities. Increasingly the Internet enables extended market-reaches and accesses to new suppliers and customers, which can lead to improved value chain efficiencies. However, in circumstances of market-uncertainty and ambivalence, and of difficulty in describing products and services e.g. in product developments, the businesses must rely on shared worldviews, established trust, and agreed control-mechanisms. Worldviews including social and subjective perceptions of environments can be

communicated through media-rich structures, and formation of shared worldviews promotes correct perception of problems, of sincerity and of expected behaviour. Whereas ICTs and Internet-based matchmaking processes e.g. electronic marketplaces increasingly offer possibilities to identify new business partners and opportunities, the personalised communication is required for establishing shared worldviews and trusted relations essential to high-quality production structures.

Relating these three areas of improved ICTs and DMM-technologies to the industrial value chains and outsourcing structures, it is revealed that some functions and structures get more supported than others: Developments of DMM-technologies, and consequently improved personalised communications and product development abilities, are especially supportive for the district-based operations and for time-dependent deliveries. Applied CAD/CAM-technologies enable larger flexibilities and faster responsiveness, and the personalised communication abilities are supportive for the personalised relationships and subjective analyses of fashion- and market-trends. Distributed communications and monitoring structures are also relevant for development of production skills and learning abilities, and hence highly relevant in communications with the single factor suppliers in e.g. Poland. Numerical information as EDI-messaging and e-mail are relevant for transmitting order and production data and for the replenishment structures, and have become applied amongst district-based companies but also with international subcontractors. The parts of the ICTs and DMM-technologies that support information brokerage and communications of skills and worldviews may be particularly relevant for identifications of new partners where personal search-processes are to difficult and meetings are to costly or time-demanding. These applications will hence primarily be supportive in the total outsourcing model especially in Asia.

Chapter 6: Economic Theories

6.1. Introduction

6.2. Economic Attributes of Information

- Tradable Information
- Analysed ICTs and DMM-Technologies
- Summary and Conclusions

6.3. Limited Information

- Organisational Structures
- Technological Changes
- Analysed ICTs and DMM-Technologies
- Summary and Conclusions

6.4. Costly Information

- Information Searching
- Contracting
- Analysed ICTs and DMM-Technologies
- Summary and Conclusions

6.5. Industrial Economics

- Local Specific Advantages and Districts
- National Specific Advantages and International Trade
- Analysed ICTs and DMM-Technologies
- Summary and Conclusions

6.6. Conclusions

6.1. Introduction

In the previous chapters it has been revealed that a manufacturing industry like the Danish textile and clothing industry need to establish different kinds of knowledge. These knowledge-forms are obtainable through different information and communication-processes of which the personalised communication is essential in establishing shared worldviews, trustworthiness and for learning, and shared workspaces are important for communicating product-requirements. Other information-processes are also important for the organisation of value chains e.g. sales, order and production data. These information and communication-processes have been presented and applied in the communication model of chapter five. This chapter instead establishes how information and communication is perceived in some established economic theories.

Information has been given much attention in economic theory. At the more abstract levels, information is related to market-clearance, where producers and consumers are assumed informed about market conditions, preferences etc. Hence, information relate to the matchmaking mechanisms at markets, where improving ICTs yields greater precision[520]. At a more concrete level, information has been treated as a commodity in itself and as a crucial input: information as a resource in production. But, information and communications have also been granted other less concrete entities: information is the accumulation of knowledge and embedded in organisational language[521], organisational learning[522], in capital[523], or it is embodied in money that symbolises the know-how in production[524]. Information becomes hidden within physical and structural entities, and thus transcends all economic activities. Information technologies that shift the societal level of information processing will result in a paradigmatic shift in economic organisation[525].

This chapter contributes with an insight to how information and communication-processes and technologies have been treated in economic theory. Information has been recognised as an important

[520] Mansell, Robin (1992): "Information, Organisation and Competitiveness – Network Strategies in the 1990s", in Cristiano Antonelli (ed.): "The Economics of Information Networks", Elsevier Science Publishers, The Netherlands, pp. 217-228.
[521] Rullani, Enzo & Antonello Zanfei (1988): "Area Networks: Telematic Connections in a traditional Textile District", in Cristiano Antonelli (ed.): "The New Information Technology and Industrial Change", Kluwer Academic Press, Boston, pp. 97-113.
[522] Lamberton, D. (1992): "Information Economics: Introductory Remarks", in Cristiano Antonelli (ed.): "The Economics of Information Networks", Elsevier Science Publishers, The Netherlands, pp. 29-34.
[523] Monk, Peter (1992): "Innovation in the Information Economy", in Cristiano Antonelli (ed.): "The Economics of Information Networks", Elsevier Science Publishers, The Netherlands, pp. 35-50.
[524] Babe, Robert (1995): "Information Industries and Economic Analysis: Policy-Makers Beware", in Robert Babe: "Communication and the Transformation of Economics", Westview Press, Oxford, pp. 9-20.
[525] Freeman, Christopher (1988): "Economic issues", in IEE Colloquium on 'Information Technology – Engineering the Future'", Digest No. 23, pp. 1-3.

component of the economic activity and decision-making, which has been reflected in the numerous approaches to information-processes and applied ICTs. Different theories have granted information different roles and treated information processes differently as they have had different perspective and objective. A common feature is that they perceive information from a quantitative perspective: emphasising volumes of transmitted and shared data. Much less attention is given to qualitative aspects, which are required for qualitative market-analyses and shared development-programmes[526], and enabled through media-rich communications and interactivity in production processes and decision-making. Similar results have been identified through other processes: highly uncertain and equivocal technology or market-conditions require subjective analyses and media-rich communications. Uncertainty calls for large volumes of information, whereas equivocality calls for high quality of information[527]. Identification of the theoretical understandings of information processes and technologies is based on classification of core statements in the selected theories[528]. These invariable cores are subsequently discussed in relation to the communicative activities proposed in the model in chapter 2, and expressed in the presented case in chapter 5.

Table 6.1: Theoretical approaches and impacts from DMM-technologies

	Analytical units	**Economic conditions**	**Rules**	**Impacts from DMM**
- New Economy - Information	Information & ICTs	Transmittable, Tradable & Standardisation	Network externalities	Services & Globalisation
- Institutional - Evolutionary	Organisations & Technologies	Bound rational & Learning	Routines & Path dependency	Knowledge formation & Specialisations
- Institutional - Transaction Costs	Transactions	Bound rational Opportunism & Asset specific.	Costs of search and contracting	Brokerage, Specifications & Outsourcing
- Industrial - Districts & International trade	Businesses, Value chains & Industries	Production costs & Proactive strategies	Scale, Networking & Alliances	Trust & Efficiency

[526] Fornengo, Graziella (1988): "Interorganisational Networks and Market Structures", in in Cristiano Antonelli (ed.): "The New Information Technology and Industrial Change", Kluwer Academic Press, Boston, pp. 115-132.
[527] Daft, Richard & Robert Lengel (1986): "Organisational Information Requirements, Media Richness and Structural Design", in Management Science, Vol. 32, pp. 554-571.
[528] Core statements according to Lakatos denote an invariable core that is refutable within a given research paradigm: see Knudsen. Christian (1991): "Økonomisk metodologi" (Economic Methodology), DJØF Forlag, Copenhagen.

Neo-classical economic theory has been criticised for being too abstract and incapable of explaining the diversity of businesses. The theoretical constriction is based on universal production-functions, full information, perfect rationality etc. Its analysis is based on allocating resources given that all agents are rational, preferences and technologies are taken for granted, and only form for institutions are impersonal markets that exists to exchange commodities and equalising prices. If there are any variations in businesses they can only reflect differences in accesses to resources. The theory holds a focus on static equilibrium, where dynamic features of competition relate to exogenous shifts in preferences or technology, which leads to a shift in equilibrium. Information is taken for granted: technological innovations and applications of ICTs have no other impact than shifting the universal production cost curve downwards[529]. This theoretical approach does not provide any interesting approaches to the role of information or any satisfactory analysis of continuous technological developments, and will hence not be perused further.

First string of economic analysis outlined below i.e. New Economy deals with the economic attributes of information as a commodity, and how applied ICTs assist the information and communication-processes. Attentions have primarily been given to the seperability of information from the production processes, the transmittability of digitised data granting instantaneous, distributed transmissions, and the reproducibility of information, which minimises the variable costs in production. Applications of ICTs impact all these attributes, and enhance the abilities for tradability of information services.

Second string i.e. evolutionary economy relates to how individuals and businesses act in situations of limited information. In this approach bounded rationality marks the individuals' behaviour, that in order to avoid the insufficiency in decision-making has to construct routines and rule-based institutions. Agents are positioned in dynamic environments and the behavioural routines are assumed rigid based on past experiences and personal motivations, but may evolve through innovative processes and learning. Applied ICTs may impact the individual levels of restricted rationality, but primarily impacts the organisational routines through improved feedback-mechanisms, product developments and learning processes.

In the third string of theoretical analysis on information investigated in this chapter i.e. transaction cost, the analytical questions relate to why information is costly and under which circumstance to

[529] Babe, Robert (1995): "Communication and the transformation of economics", Westview Press, Oxford.

expect which costs. Costs of information and transacting relate to the information requirements, searching and contracting issues, which differ within markets and hierarchies. Any economic activity is govern by the needs for information and hence engulfed in transaction costs, and the conditions of transaction costs have been related to bounded rationality, opportunism and asset specificity. Applied ICTs have impact on both internal and external information processes, and can hence shift the barriers between markets and firms.

Industrial economics are also given special treatment in the below sections. Industrial economics emphasise the special conditions that enrich specific organisations and the environments that impact the competitive advantages of firms, local areas and nations. Information and communication processes are not granted any independent explanatory powers, but may impact competitiveness indirectly through information abilities of individual firms, just as local and national information infrastructures will be influential. Telecom infrastructures and business applications of ICTs impact value chain structures and industrial organisations.

6.2. Economic Attributes of Information

Economic activity hinges on acquisitions and handling of information. This information-cantered approach has been given renewed attentions as developments within ICTs and DMM-technologies have shifted the structural boundaries for information processing. Indeed substantial parts of the New Economy is concerned with the economic characteristics of information. Developments in storage-capacities, processing-abilities and transmission-bandwidths have altered the ways in which information is created, reproduced and distributed, which impact the associated economic activities. Besides perceiving information as an entity, information may also be treated as an intrinsic value of economic organisations and institutions and as such information will relate to knowledge about production-processes, demand situations etc. These differences relate to values of information in use and values in trade, which are interrelated. Information can be treated either as a factor in production or as a tradable commodity:

> "As a factor of production, information is an input in the process of producing outputs, and in this case economists compare the costs of attaining information with the reduction in costs attributable to its use. At the margin, the cost saving from applying information should equal its acquisition cost. As a final commodity, the quantity of information produced or made available for sale should be such that, at the margin, the price paid equals its cost of production and distribution." (Babe, 1995[530]).

[530] Op cit: Babe (1995), p.15.

A crucial aspect of information analysis in the New Economy is that information should be treated from both these perspectives: information is a commodity tradable like other commodities, but is also an input to production and market operations, which denotes its value in use. Though the concept of the New Economy has originated in an interest in describing the societal relations and economic transformations of the late 1990s, emphasis has now become almost exclusively on information networks and applied ICTs[531]. Contributions on the New Economy strongly emphases the unique characters of information and information processing, centred on the concept of information: as separable, transmittable and tradable.

Information is the analytical core unit in the New Economy, which grant the analytical model a fine approach in dealing with impacts from innovations in ICTs. This approach also implies that individual agents and businesses are of little relevance in the economic explanations, which leaves the theoretical contribution without powers to explain individual behaviours and the varying approaches taken by businesses dealing with same information contents. The model can through discussions of information and information flows analyse industry level organisational changes related to altered information services. Less clear is the analytical powers in analysing business strategies and the behaviours of individual businesses.

Tradable Information

Applying marginalist economic analysis, as done by Babe above the costs from producing and acquiring information should equalise the expected gains from application. This kind of analysis is interesting as it points to the dual aspects of information supply and demand, but is complicated by the unique nature of information that distinguishes it from most physical goods. These issues are stipulated below.

Information is by nature a public good, which make exclusion in use quite complicated. Being a public good implies that several consumers can use the same good at the same time, without exclusion of other users. This also implies that the information provider is faced with potential competition from those that have bought their information services. Whenever information has been transmitted the supplier looses control, as there are no limitations to whom that can use the information. Attempts

[531] Atkinson, Robert & Randolph Court (1998): "The New Economy Index", available at www.ppionline.org November 1998, pp. 1-50.

have however been made to restrict the limitless redistribution of information e.g. patented rights, copying rules, contracts and special information standards[532].

Many information goods are not only public goods they are also marked by high production costs and relatively low costs in coping[533]. Processes of producing information goods are based on collecting relevant data, analysing it and restructure is for sale. Provisions of information services are enriched by economy of scale, and services providers extract value through offering high qualities and values of the provided information. Whereas production is resource-dependent, reproduction is very easy through file coping i.e. there are increasing returns to scale, which complicates the trade in information goods[534]. Another complicating issue is that information is "experience goods": there are no guarantee that the value in trade reflects the value in use to you, you have to possess it before you know. Reputations and reviewing may be ways to avoid pitfalls of buying information goods that do not deliver the expected values.

Another attribute if the information economy is that data is generated and extractable from everywhere[535]. As products increasingly have incorporated microprocessors in them they contain structures to generate information. Data hence become extractable from any product from any place, which lead to overwhelming levels of data. A challenging aspect of being networked is not to access the data but to restrict data to what is relevant and necessary[536]. Data analyses and the provisions of qualitative information service are value-added services to economic agents in order to avoid information overload. Existence of specialist service providers can also generate extra values through structures to generate individually fitted services; information providers hold economy of scale in analysing information and can easily provide personalised information services through incorporation if individualised input data.

Related to these issues are that information is extractable from any point, separable from production and consumption, and transmittable immediately across distances within worldwide electronic networks[537]. In practice information is separable and transmittable, and can be collected by specialised

[532] Varian, Hal (1998): "Markets for Information Goods", Working paper, pp. 1-19.
[533] Shapiro, Carl & Hal Varian (1999): "The Information Economy", in Carl Shapiro & Hal Varian: "Information Rules", Harvard University Press, pp. 1-18.
[534] Op cit: Varian (1998).
[535] Cohen, Stephen et al (2000): "Tools for Thought: What is New and Important About the "E-conomy"?", BRIE working paper, No. 138, pp. 1-65.
[536] Kelly, Kevin (1999): "New Rules for the New Economy", Penguin Books, New York.
[537] Shaw, Michael (2000): "Electronic Commerce: State of the Art", Michael Shaw et al (eds.): "Handbook on Electronic Commerce", Springer, Berlin.

information service providers who can provide general or customised analyses of e.g. markets, products, fashions, and technologies. These specialist service providers will gain competitiveness through the economy of scale in collecting data and in producing information goods:

> "As the market grows in these dimensions, there will appear a set of firms which specialise in collecting and selling information. They may take the form of trade journals or specialised brokers. Since the cost of collection of information is (approximately) independent of its use (although the cost of dissemination is not), there is a strong tendency toward monopoly in the provision of information: in general, there will be a "standard" source for trade information." (Stigler, 1961[538]).

These abilities have been highlighted as a major renewal of the economic structures and led to arguments for the death of geography[539]: the specialised information providers can in principle be anywhere as long as they are connected to electronic networks.

Transmission technologies and processes of information have further implications for the usability and value of information. The transmissions of information are not mediated through limitless networks, instead information gets transmitted through restricted networks: restricted in reach and in data structure. Instead of perceiving the networking abilities as one global structure, networking is as yet marked by limited bandwidth, incompatibility of communication standards and structures. However, due to the much-emphasised positive feedback mechanisms of electronic networks[540&541], which dictate that values in usage will rise with numbers of connected nodes, a single communication standard may be expected. With only one structure and a universal communication standard the abilities to share information are vastly improved. A path-braking attribute of electronic networking is the networking externality related to its usage, combined with the economy of scale in provision of information services[542&543].

Analysed ICTs and DMM-Technologies

Attentions of the New Economy have increasingly been given to the development of particular networks and transmission standards, just as attentions have been given to the impacts form increased

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[538] Stigler, George (1961): "The Economics of Information", in Journal of Political Economy, Vol. 69, pp. 213-225, p. 220.
[539] Kenney, Martin & James Curry (1999): "E-commerce: Implications for Firm Strategy and Industry Configuration", in BRIE working paper, E-conomy project, Vol. 2, pp. 1-27.
[540] David, Paul (1992): "Information Network Economics – Externalities, Innovations and Evolution", in Cristiano Antonelli (ed.): "The Economics of Information Networks", Elsevier Science Publishers, The Netherlands, pp. 103-106.
[541] Arthur, Brian (1990): "Positive feed-backs in the economy", in Scientific American, pp. 80-85.
[542] Op cit: Shapiro & Varian (1999).
[543] Hayashi, Koichiro (1992): "From Network Externalities to Interconnection – The Changing Nature of Networks and Economy", in Cristiano Antonelli (ed.): "The Economics of Information Networks", Elsevier Science Publishers, The Netherlands, pp. 195-215.

information levels on product and service provisions[544]. Three aspects are particularly important to the textile and clothing industry: development of communication structures and growing compatibility, transmittability of information and economy of scale in information-processing leading to specialised service provisions, and finally, enhanced information levels and communication tools, which assist product integrations and improved information searches

To a wide extent the electronic networks have been understood as complimentary: facsimile, EDI-messaging, CAD-CAM-files etc., and within these networks there exists competing sub-networks based on different and incompatible transmission standards[545]. As these networks are enriched by positive feedback structures, there will be competition amongst the different standards, where the winner will take it all. First-mover advantages are outspoken[546], just as the abilities to generate a critical mass of users are thought crucial to winning the standardisation race[547]. A new rule related to this standardisation race of the New Economy is to give (networking) products away for free and then later, when the competition has been won extract revenues i.e. a gift economy[548]. A noticeable development is the diffusion rates of the Internet and its abilities to transmit various types of information based on competing standards. The hypertext transmission protocol and time-stamped transmissions make the Internet applicable for universal data sharing and for distributed interactivity. As uniform communication structures develop a universal language develops that enable information to be shared, communication to be enhanced and business interactions to be smoothened[549&550].

A second major concern to the analyses in the New Economy relates to the impacts from applied ICTs on the service provisions and conditions for production. Partly in response to and partly as a consequence of applied ICTs markets have become more dynamic and changeable, which compel businesses to structure for changes. Networking of businesses has been widely recommended, as it enables higher levels of production flexibility and enhanced information sharing[551]. Structures for better information sharing will in this perspective impact the information processes: enhancing transfer

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[544] Op cit: Monk (1992).
[545] Op cit: Kelly (1999).
[546] Liberman, Marvin & David Montgomery (1988): "First-mover Advantages", in Strategic Management Journal, Vol. 9, pp. 41-58.
[547] David, Paul (1995): "Standardization policies for network technologies: the flux between freedom and order revisited", in Richard Hawkins et al (eds.): "Standards, innovation and competitiveness", Edward Elgar, London, pp. 15-35.
[548] Op cit: Kenney & Curry (1999).
[549] Brusseau, Eric (1994): "EDI and inter-firm relationships: toward a standardization of coordination processes?", in Informaiton Economics and Policy, Vol. 6, pp. 319-347.
[550] Foray, Dominique (1995): "Coalitions and committees: How users get involved in information technology (IT) standardization", in Richard Hawkins et al: "Standards, innovation and competitiveness", Edward Elgar, UK.
[551] Castells, Manuel (1998): "The Rise of the Network Society", Blackwell Publishers, Oxford.

of tasks to specialist service providers and increase outsourcing. Enhanced abilities to collect and transmit information will potentially lead to new products and services fitted the individual consumers, inclusion of new specialised information and service providers, and a shift of powers towards the information industry[552]. Notably the developments of worldwide Internet structures and universal communication standards have the potential to redistribute locations of information tasks, impacting industrial organisations and international divisions of labour.

In addition to the enhanced information processing tools in support for specialised information services, tools also develop that assist the individual business. On one side, the digitisation of production processes and value chain management will enhance the information levels throughout the chains. Hence, ICTs assist information sharing and general lifting in information levels e.g. through shared workspaces, distributed monitoring and feedback structures. On the other hand, search tools and applied DMM-technologies enhance the abilities by individual businesses to do qualitative analyses and to identify new business partners without specialist information grocers, authentity and guarantee providers, electronic marketplaces etc. XML-based data structures and worldwide reach of the Internet increase to scale of searches, and applied DMM-technologies improve communications of worldviews and evaluation of trust.

Summary and Conclusions

Theoretical analyses of information and ICTs in the New Economy highlight the enhanced transmittability of information, separation of information from production, dislocation of service providers, and competing network structures. Consequences of the enhanced abilities to share information are industrial restructurings based on new modes of networking, global provision of new services and products, development of new service providers, and shifts in power structures emphasising the information providers and the enabling industries.

There can be little doubt that many of these characteristics can be identified in the Danish textile and clothing industry. Markets have become globalised and more volatile, which have compelled businesses to gear for changes obtainable through improved information sharing, networking structures and enhanced outsourcing. Networks of collaborations are found in the value chain structures, where businesses share information about production issues and market trends, which assist better responsiveness to market alterations. Consequently businesses have become more integrated and

[552] Op cit: Cohen et al (2000).

interrelated. However, the networking structures in this industry predate the widespread applications of ICTs: ICTs have been assisting but not initiating the networking structures.

Rapidly changing market conditions are one of the primary drivers for applications of ICTs. Traditional communication tools like voice telephony and faxes are widely applied and still essential to many businesses. Networking by firms is supported by applied ICTs: e-mails and EDI-messaging are especially relevant for value chain management, CAD/CAM-files for product development and integration, and the Internet for information searches, market and fashion analyses. Whereas e-mailing is highly suitable for transmissions of unstructured information and almost universal in its nature, EDI is much more restrictive: highly structured. Technological developments have enabled that EDI-transmissions be mediated globally through the Internet, and industry-wide definitions of EDIFACT standards e.g. EDITEX assist worldwide structures of information sharing. Sharing of CAD/CAM-files is still impacted by proprietary standards, but initiatives have been taken to enhance Internet-based interactivity amongst competing products and standards.

Electronic networking and diffusion of the Internet have enabled new forms of information provision and new services. Online accesses to information have become possible by businesses and by consumers that can browse for products, prices, and supplier characteristics. The Internet also provides a direct channel between consumers and businesses: personalised information and requirements can travel upstream the value chains, just as information goes from suppliers to consumers. Increasingly, information provided by specialised service providers get provided online e.g. by district institutions, and market and fashion analysers. Notably a range of electronic markets has developed, which offers new modes of matchmaking based on products, technologies or skills. Electronic marketplaces, magazines and other specialist providers increasingly offer additional information related to market and fashion analyses, legal and technological issues etc. Entirely new services emerge related to use of ICTs such as data warehousing, online shops, and outsourcing of computer capacities in marker making and in centralised storage of digitised patterns. And digitisation of processes transforms the industrial structures where virtual product presentations not only enable individualised online alterations, but also transform the established processes of physical prototyping for fashion shows, fairs and shops. Virtual presentations enable that skills be presented, models be adjusted and orders received before manufacturing.

Whereas the transmissions of information are immediate and performed at low costs, the physical products are not. Globalised information transmissions have enabled that some information services

have become dislocated from physical production sites i.e. the outsourced design processes and position of electronic marketplace. However, major parts of these services remain geographically rooted: Regional electronic marketplaces, Danish provisions on legal information, district-wise storage of digitised patterns, and regional market analyses. Physical production processes are geographically confined marked by regional production skills, factor costs, and by transportation costs and time.

Applications of ICTs have assisted better information sharing for demand forecasting, enlarged responsiveness to market changes and increased internationalisation of provisions through higher levels of information sharing. Information processes relate to sharing of production and sales data for early warnings, but also relate to multimedia-based information sharing: web-cameras enable distributed monitoring and communications of worldviews. Sharing of CAD/CAM-files enables smooth transfers of production data, production integration, and a distributed, shared workspaces for product developments.

An evident trend from the presented case is the shifts in industrial powers from the large manufacturers that dominated the national markets in the 1980s towards the retailers, which hold the direct information link to consumers. Retailers have unique information accesses, which give them increased knowledge levels they can utilise in improved cooperation with established suppliers or in identification of new suppliers in search for better matched provisions. Needs for enhanced market knowledge and direct access to customer-information have led to increasing mergers between manufacturers and retailers, manufacturers' establishment of own stores, factory outlets and online sales. With the development of the Internet and the increasing penetration rates for private households and businesses, combined with the enhanced abilities to present and modify products through Internet-based shared DMM-files manufacturers are set to gain a new important market channel.

A crucial element of the applied ICTs and networking structures is the potential for mass-customised provisions. Value chain operations have increasingly shifted from supply-push towards demand-pull structures, which is based on better information about and knowledge of market segments, and personalised requirements. Abilities to incorporate customer requirements into value chain structures enhance the potentials for development of new products and for better market mechanisms where the supply gets better suited to match the current demand. Levels of risks for manufacturers and retailers alike are reduced evidently, and sell-outs or overstocking will be reduced.

Theoretical contributions on the New Economy are capable to identify many of the features identified in the Danish textile and clothing industry. These theoretical contributions are related to information exchanges, tradability of information and impacts on industrial structures. Projected impacts from applied ICTs on globalisations and new service products are identifiable, but other explanatory factors seem to be needed as well: new service provisions remain geographically rooted, restructuring of value chains and internationalisation of production relate mostly to issues of costs, time and quality. Trends of internationalisation are detectable related to the enhanced market reach and disintermediation enabled by the Internet, but physical distribution of products remains costly and requires much time.

As compared to the introduced communication model from chapter 2, there are many similarities but also some notable differences. As stated, the unit of theoretical analysis in the New Economy is information, whereas it is agents and businesses that are central in the proposed model. This leads to differences in approaches and emphases, and also to minor discrepancies in conclusions. Deviating approaches result in different interpretations of enhanced ICTs, which in the model are related to bounded rationality and knowledge formation. Implicitly, the role of information differs: information and communication enhance knowledge in multiple fields required for value chain operations and production. The New Economy instead ascribes information to service provisions that are transferable and tradable, and that qualitative levels of information relate not to communication and perception but to analysed or personalised services.

6.3. Limited Information

Theoretical contributions on economic activities seem increasingly concerned with dynamic market alterations, firm differences, disequilibria, and technological changes[553]. An important tool to deal with these economic activities has been to introduce limited information access, bounded rationality[554] and evolutionary developments[555]. Renewed interest in dynamic economics have to deal with growing diversity of businesses, which have been expressed in new macro-level identification of changing competitive conditions e.g. monopolistic competitions[556,557&558]. Or in a micro-level economic

[553] Blaug, Mark (1992): ”Economic Theory in Retrospect”, Cambridge University Press.
[554] Introduced by Herbert Simon, discussed in Christian Knudsen (1993): ”Equilibrium, perfect rationality and the problem of self-reference in economics”, in Uskali Mäki et al (eds.): ”Rationality, institutions and economic methodology”, Routledge, London, pp. 133-170.
[555] Nelson, Richard & Sidney Winter (1982): ”An Evolutionary Theory of Economic Change”, Harvard University Press.
[556] Auerbach, Paul (1989): ”The Concept of Competition” in Paul Auerbach: ” Competition, The Economics of Industrial Change”, Basil Blackwell, London, pp. 7-30.
[557] Best, Michael (1996): ”The New Competition – Institutions of Industrial Restructuring”, Polity Press, London, Introduction, pp. 1-26.

analysis, which emphasis internalistic approaches and behavioural assumptions e.g. expressed in the phylogenetic approach found in genes-based evolution: Darwin and Lamarck[559].

Attentions to the internalistic motivations of economic agents and an assumed limitation to information have meant that rule-following institutions have been introduced. A set of neo-institutionalist and evolutionary contributions has emerged based on much broader behavioural foundations than in neo-classical economics with focus on economic processes instead of static snapshots, and with inclusion of non-market institutions[560]. Despite evident similarities there are also substantial differences between these approaches related to the unit of analysis, and treatment of bounded rationality and rule-following institutions i.e. the functionalist rationality in transaction economics vs. procedural rationality in evolutionary and path-dependent theories[561]. Procedural rationality denotes the interactive behavioural routines or procedures that mark economic agents in changeable environments: routines get based on expectations of future events. Functionalist rationality instead denotes a static optimisation rule that does not alter with the accumulation of experiences and knowledge.

Within the neo-institutional, evolutionary paradigm it is assumed that information is restricted. Restrictions are founded either in limited access to information or limited abilities to process all relevant data, which also impacts their abilities to act fully rationally and optimise activities. With bounded rationality agents cannot foresee full consequences of their actions nor know every relevant thing about production processes, markets developments, and technological innovations: they are left without opportunities to know whether their chosen actions will actually be optimal. Instead the agents get forced to apply some rule-following mechanisms in their decision-making, which are based on past experiences, established knowledge, and present situation. Rule-following institutions are rigid and somewhat fixed, which make them invariant to temporary fluctuations. Decision-taking routines are quite static and only evolve gradually through trial and error processes, based on innovative activities and learning capabilities.

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[558] Miles, Raymond & Charles Snow (1984): “Fit, Failure and the hall of Fame”, California Management Review, Vol. 26, pp. 10-28.
[559] Hodgson, Geoffrey (1994): ”Evolution, Theories of Economic”, in Geoffrey Hodgson et al (eds.): ”The Elgar Companion to Institutional and Evolutionary Economics”, Edward Elgar, Aldershot, England, pp. 218-224.
[560] Langlois, Richard & László Csontos (1993): ”Optimization, rule-following, and the methodology of situational analysis”, in Uskali Mäki et al (eds.): ”Rationality, institutions and economic methodology”, Routledge, London, pp. 113-132.
[561] Knudsen, Christian (1993): ”Modelling Rationality, Institutions and Progresses in Economic Theory”, in Uskali Mäki et al (eds.): ”Rationality, institutions and economic methodology”, Routledge, London, pp. 265-299.

Bounded rationality has been analysed from multiple perspectives and related to different situations of which two are especially important to the present analysis: organisational routines and learning, and the path-dependent technological developments. These are analysed below.

Organisational Structures

All economic agents are marked by bounded rationality both in limited information and in limited abilities to analyse all relevant information. Bounded rationality also impacts the nature of organisations as they cannot obtain full knowledge either, and hence not ensure full rationality of their actions. Instead of attempting to analyse all available information and all possible events, organisations instead apply dome rule-following routines that stipulates how to do in different known situations. Organisational routines relate to three different levels of organisational activities: standard operation procedures, investment rules and organisational innovations[562]. The first denotes how to produce and organise available resources, the second on which kind on human resources and technologies they apply. And the final denotes search procedures in attempts to produce better organisational structures and technologies.

Organisational routines are in this view perceived as the gene of the company that gets reproduced from period to period through organisational activities. These organisational routines are unique to each business, as they have developed through time based on factor endowments, innovations and learning abilities[563]. The organisational genes or routines themselves do not get exposed to a selection mechanism; instead they impact the business performances and productions, which are exposed to selection mechanisms at the dynamic markets[564]. Interpretations of information feed back from the competitive environment are crucial in determining viability of present routines but the feedback mechanisms are potentially erroneous: results get misinterpreted, chance events impact on results, and wrong information is received. This leaves the firm with little exact knowledge and few precise indicators for the needs to change routines. Mutations can be perceived as be purely blindfolded or random as assumed in Darwinist natural science:

> "Like in the Darwinian natural selection, we should not presuppose that the success or survival of individual firms are based on full information about the rules of the game and

[562] Op cit: Nelson & Winter (1982).
[563] Cohendent, Patrick & Patrick Llerena (1997): ”Learning, Technical Change and Public Policy”, in Charles Edquist (ed.): ”Systems of Innovations”, Pinter, London, pp. 223-241.
[564] Dosi, Giovanni & Richard Nelson (1994): ”An introduction to evolutionary theories in economics”, in Journal of Evolutionary Economics, Vol. 4, pp. 153-172.

> about the other agents in it. The question of success is decided ex post rather than ex ante." (Andersen, 1998[565]).

This approach assumes that businesses have little knowledge about their performances, the competitive environment, and no abilities to predict events. Without such knowledge they would not know which way to turn when they change routines. Analysis of business diversity, which where one of the objectives of the neo-institutional and evolutionary theories, then hinges on chance events: businesses differ due to their different resources, different strategies founded in the routines, by feedback from markets and totally random mutations.

Business diversity may however be impacted by differences in abilities to analyse feedback and to determine what kind of improvements that are needed to the organisational routines. By granting businesses with knowledge and abilities to interpret information from feedback channels, the businesses may learn and engage in purposeful mutations[566]. Direction-oriented innovative activities has also been introduced to the biological sphere by Lamarck, but his socio-biological approach was deemed to proactive[567]:

> "In economic terms there should be models explaining how the diversity under consideration is exposed to the related selection mechanisms. Among these models, the market mechanism explains in a static context... In a dynamic evolutionary context, different models, often inspired by biology, explain how diversity is created by some mechanisms, for instance mutations or innovations, and exposed to selection mechanisms, for instance economic competition.... we consider that innovations are not random, but an integrated part of economic activity, we shall assume a dependence between the mutation and selection mechanisms." (Cohendent & Llerena, 1997[568]).

Businesses are diverse due not only due to their initial resourcefulness, internal motivations, strategies, but also due to varying abilities in communicating with the competitive environment and to ensure useful feedback structures. The increased abilities to access information from the environments do not reverse the order of events: routines still dictate organisational performances, which impact the production outputs and performances on the market. Better feedback structures do not lead to full information, but limits the bounds to rationality, enhance abilities to act proactively but: mutations will still be potentially erroneous.

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[565] Andersen, Espen (1998): ”Approaching economic evolution”, available at www.business.auc.dk/evolution/esapapers September 1998, pp. 1-21, p. 11.
[566] Dosi, Giovanni (1997): ”Opportunities, insentives and the collective patterns of technological change”, in The Economic Journal, Vol. 107, pp. 1530-1547.
[567] Bonde, Niels et al (eds.) (1996): ”Naturens historiefortællere”, GAD, Copenhagen.
[568] Op cit: Cohendent & Llerena (1997), p. 226.

Purposeful organisational changes based on analysis of the information generated through the feedback structures from the environment can also be called learning. Learning is indeed the cumulative development of skills and knowledge, which becomes expressed in better organisational routines[569]. Learning denotes the processes through which resources develop into capabilities and capabilities into core capabilities[570]. Capabilities develop as the resources get combined with the organisational routines on how to do things, which continuously get assisted through information loops and feedback. Organisations gradually develop skills and capabilities through information and learning loops from internal resources and external environment, and the individuals gradually develop through interactions with the organisational knowledge. Structures of the feedback loops govern the learning processes. Enhanced communication structures will give better abilities to understand the true content of the feedback and will aid businesses in improving learning procedures.

Another but still related approach to the learning mechanism relates information processes and learning abilities in knowledge formation[571]. Contributions on the learning economy have very strong emphases on the learning abilities that result in better performances. The better performances have in the above outline been related to formation of organisational genes exposed to biological mutations and selection mechanisms, but could instead be related to stocks of knowledge. Hence, information and communications get related to generating knowledge about how to produce, what to produce, who to produce with and knowledge of why, as the "principles and laws of motion in nature, humans and society"[572].

Numerous factors impact the learning abilities and performances of individual firms. Being constituted by its initial resources and organisational routines a business may develop through employing new resources, or by changing the organisational routines e.g. changing decision-taking structures or through increasing R&D. As evaluation of organisational mutations depend on feedback from the external environment, information processes may be upgraded and enhance integration between learning and selection. Internal feedback loops are also instrumental in upgrading internal resources, and improved learning abilities. But internal and external information loops are not only subject to the

[569] Levinthal, Daniel (1996): "Learning and Schumpeterian Dynamics", in Giovanni Dosi & Franco Malerba (eds.): "Organization and Strategy in the Evolution of the Enterprise", Macmillan, Basingstoke, pp. 27-41.
[570] Andreu, Rafael & Claudio Ciborra (1995): "Organisational learning and core capabilities development: the role of IT", in Strategic Information Systems, Vol. 5, pp. 111-127.
[571] Lundvall, Bengt-Åke & Björn Johnson (1994): "The Learning Economy", in Journal of Industry Studies, Vol. 1, pp. 23-42.
[572] Lundvall, Bengt-Åke (1998): "Why Study National Systems and National Styles of Innovation?", in Technology Analysis & Strategic Management, Vol. 10, pp. 407-421.

structures of the individual firm, they are also impacted by its position in the external environment i.e. individual firms gain from being located in particular information rich or skill-full districts[573] or nations[574].

Improvements of organisational performances can thus be related to three fundamental entities: Firstly, employed resources, human and technological, through which the firms operate, organise and develop capabilities. Secondly, the organisational routines related to production processes, investments and innovations. Compositions of the organisational routines are specific to each firm dependent on its strategies e.g. more or less innovative, and employed resources e.g. more or less skill-full employees. Thirdly, to the information processes and feedback mechanisms from the environment and internally. Enhanced information structures partly enhance internal learning processes and partly lead to better knowledge formations about market responses and hence to improved mutation processes. Intensive information sharing programmes with business partners are especially helpful in generating useful knowledge.

Technological Changes

The second major application field for evolutionary economics is the analyses of technological changes. Information about technologies and knowledge about their suitability for the particular business are important in making the right choices on new technology. But due to the bounded rationality decision-makers are limited in information access and knowledge and must rely on other measures. They may decide on new technologies given employed resources and acquired skills, get accustomed to the new technology, and attempt to develop it further. This developmental process will lead to continuous, gradual and irreversible improvements in established technologies i.e. a technological trajectory, and not lead to any technological paradigmatic shifts. Technologies develop gradually and hence are the decision-makers incapable of knowing, which technology that will be the most suitable in the long run.

Another source for imperfect knowledge is when technological developments are not sector or firm specific and the technological developments depend of factors unknown to the decision-maker. This is especially evident in cases of networking externalities and with positive feedback: Imperfect

[573] Maskell, Peter & Anders Malmberg (1995): ”localised Learning and Industrial Competitiveness”, available at http://brie.berkeley.edu, December 1999, pp. 1-29.
[574] Lundvall, Bengt-Åke (ed.) (1995): ”National Systems of Innovations – Towards a Theory of Innovation and Interactive Learning”, Introduction, pp. 1-19.

knowledge is caused by the unpredictability of which technological developments or standardisation processes that will eventually be dominating[575&576].

Due to the incomplete knowledge of agents and unpredictable values of available and future technologies, they will postpone own decision-making, observe and copy what other agent choose[577]. Simple herd behaviour may occur if agents disregard own preferences and heedlessly resolve to the same choices as other[578]. Simple copying rules make good sense in cases of positive feedback and network externalities as in the development of ICTs: where the increasing number of users accelerates the values of the network. Positive feedback processes and path dependent developments have frequently been linked to developments of communication networks and standards. As developments are path dependent leading to gradual irreversible changes, the chosen path get reinforced by the network externalities and almost impossible to alter. This has led to compelling arguments for collaborative activities in standardisation processes[579].

Path-dependent developmental processes are not only detectable in cases of networking externalities but also with other technological developments. Technological trajectories emerge through evolutionary paths based on innovation processes related to know technologies, employed resources, capabilities, organisational learning and environmental structures[580]. Choices on which technologies to employ are not only subject to organisational capabilities, but also impacted by external relations. The external environment contributes to the learning processes and upgrading of skills and capabilities, and hence it will be preferable for a firm to apply the same technology as the by the environment[581]. Hence, a reinforcing process emerges like the networking externalities where the more users there are of a given technology the more skilled will the environment be and the more likely it is that technologies will be improved.

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[575] Op cit: David (1992).
[576] Op cit: Arthur (1990).
[577] Heiner, Ronald (1988): ”Imperfect decisions and routinized production: implications for evolutionary modelling and initial change”, in Giovanni Dosi et al (eds.): “Technical Change and Economic Theory”, Pinter Publishers, London, pp. 148-169.
[578] Banerjee, Abhijit (1992): “A Simple Model of Herd Behaviour”, in Quarterly Journal of Economics, Vol. 107, pp. 797-817.
[579] Besen, Stanley (1995): ”The standardsprocesses in telecommunications and information technology”, in Richard Hawkins (ed.): “Standards, innovations and competitiveness”, Edward Elgar, UK, pp. 136-146.
[580] Op cit: Dosi (1997).
[581] Dosi, Giovanni & Luigi Orsenigo (1988): ”Coordination and transformation: an overview of structures, behaviours and change in evolutionary environments”, in Giovanni Dosi et al (eds.): “Technical Change and Economic Theory”, Pinter Publishers, London, pp. 13-37.

Analysed ICTs and DMM-technologies

Institutional economic theory in its evolutionary forms contributes to analyses of economic activity in the face of improved information sharing and ICTs in two ways. Firstly it deals with the enhanced information levels and feedback mechanisms enabled through applied ICTs and DMM-technologies, which impact learning mechanisms, knowledge formations and organisational performances. Secondly, it contributes to analyses of the developmental processes of the communication technology itself, where evolutionary path-dependent traits in innovations and learning condition the sector-specific applications.

Evolutionary analyses offer an economic approach to analyse the roles of information and applied ICTs, which relates to economic activities given limited information access and bounded rationality. Agents have limited information access and restricted abilities to handle information and generate knowledge. Applied ICTs and DMM-technologies will in this light improve the information access from the environment leading to better learning structures and enlarged knowledge levels.

In the biological approach to economics with either Darwinist blindfolded or Lamarckian direction-oriented mutations the businesses are given by their organisational routines as genes. Genes and employed resources dictate the economic performances of businesses that get exposed to selection mechanisms at markets. Enhanced information processes will improve the abilities to interpret the feedback received from the environment, and with better information the organisation gets better positioned to make direction-oriented alterations or mutations. Through feedback loops the business get informed about performances, which enhance abilities to learn – both internal and external loops become important in upgrading internal resources to core capabilities and to improve organisational routines. Feedbacks are also instrumental in accumulating information and knowledge generated through communicative activities. ICTs are especially applicable in providing speedy information feedbacks of quantitative information e.g. structured EDI-messages. DMM-technologies are especially viable in enabling media-rich and interactive communications applicable for shared product developments, market and fashion analyses etc. Hence, ICTs and DMM-technologies can be perceived as tools for upgrading information processes, limiting bounded information and rationality, and enhancing organisational routines and knowledge formations. Through applied ICTs and DMM-technologies, the firms will get better and faster feedbacks that position them better for responding to market changes and to learn from past experiences.

Especially feedbacks from trusted or networked business partners will be beneficiary: business partners can as well as employees be trusted to express truthful interpretations of the environment. Communications of these interpretations require some levels of shared communication ability, which relate to a common language:

> "In a world where agents differ in their perceptions of the environment, and where communication, acquisition of information and computation are limited and costly, coordination can only be achieved by means of the definition of a common set of rules, codes and languages which are well understood and shared by all the members of the organisation involved in a certain interaction. Routines, rules, procedures, standards, etc. become then central in the conceptual framework." (Cohendent et al, 1998[582]).

Likewise the evolutionary approach indicates how to perceive technological developments and applied ICTs. Technological developments are irreversible and path-dependent, which indicates that technologies develop gradually - the theory is ill-suited to describe radical paradigmatic technological shifts. Gradual developments seem to be the case for much production technology and may be applicable for most information and communication tools as well, as innovations seem to follow certain trajectories. Externalities in regional developments of skills and capabilities impact the choices by individual businesses to employ specific machinery that dominates in the region. Through externalities in learning processes a given technology become subject to positive feedback mechanisms and reinforced processes.

These developmental processes are also relevant in describing the developments of communication networks and standards. In these cases the externalities in use are even more pronounced which make the race for standards one where winner takes all. These kinds of developments are tightly associated with imperfect knowledge and explicable through positive feedback mechanisms, delayed decision-making and copying of decisions.

Summary and Conclusions

Information processes and technological developments are important to the evolutionary economical approach. Agents are restricted in their information capacities and improved ICTs and DMM-technologies will assist better learning processes and accumulation of knowledge, which impact the business performances, natbly through developments of core competencies and specialisation. In contrast to revolutionary paradigmatic shifts in technologies the evolutionary approach emphasise that technological innovations are gradual improvements of known technologies, which through various

[582] Cohendent, Patrick et al (1998): ”Theory of the firm in an evolutionary perspective”, Working paper, pp. 1-28.

degrees of externalities and feedback mechanisms lead to technological trajectories. Both bounded rationality and technological trajectories seem relevant in analysing the economics of the Danish textile and clothing industry.

Learning processes seem very evident within the textile and clothing industry. Businesses gradually develop their resources into capabilities and eventually core capabilities. This developmental process is evident in the impressive numbers of small and medium seized specialised enterprises that dominate the industry. Evolutionary processes are traceable to the mutations of routines where different degrees of success by the firms may be related to differences in strategies, products and performances. Incomplete knowledge about the future leads to non-optimal mutations and some degrees of business closures, which are also evident in the presented case, even within successful districts.

An important aspect of the industrial development is the enhanced level of information sharing expressed in high degrees of CAD/CAM-equipments, Internet penetration, e-mails and EDI-messaging. Applications of ICTs enable enhanced information processes where strategic data of sales and production progress get exchanged. Notably e-mailing and EDI-messaging are important tools for generating speedy and accurate feedback mechanisms from the market. DMM-based monitoring and conferencing are more applicable for discussing production qualities and for learning. Speedy, reliable information is key to the learning processes and in order to respond to market alterations: economic viability of firms in volatile environments rest with abilities to change products and structures according to needs. DMM-technologies are especially helpful in accumulating information and in generating shared knowledge e.g. on market developments, which are also essential for providing required flexibility in provisions. Virtual catalogues and shared workspaces are assisting design developments and product adjustments, through speedy, distributed processes that are needed for enhanced flexibility. Likewise, the videoconferencing tools will assist communications and knowledge formation e.g. on what to produce: shared market and fashion analyses are assisted by Internet-based searches and products presentations, by online services and by virtual meetings.

Information sharing is not only assisting the development of individual businesses or specific value chains, through externalities the individual business will impact the neighbouring environment as well. As a business develops its resources and learn how to apply different technologies there will emerge some spillovers to the neighbouring businesses based on improved localised know-how and skills. Externalities will impact that particular modes of technologies will dominate certain areas. These externalities can be related to information sharing rooted in communication structures e.g. enhanced

information sharing and exchange of experiences within value chains, or rooted in upgrading human skills e.g. mobility of labourers within a certain district. Whereas the human resourcefulness due to relative immobility of labour primarily support district-wise or national learning processes, the communications-based knowledge sharing have become internationalised with the development of the Internet and diffusions of compatible DMM-technologies. Through applications of ICTs and DMM-technologies within industries and value chains it is expected that learning processes will become internationalised even further leading to much speedier learning processes in developing regions.

Evolutionary leaning approaches are also applicable in analysing technological developments; at least to the extent they are gradual following certain trajectories. Technological trajectories seem evident within the production technologies for the textile and clothing industry. Some uniformity of developmental processes has occurred: separation of human powers from production processes and introduction of centralised power sources, mechanical standardisations and refinements enhancing equipment qualities, mechanisation and mass-producing capacities, and finally digitisation and automation. With the exception of few production technologies that are still very labour intensive, these processes have impacted all production technologies through continuous developments. In conjunction with applications of more advanced production technologies the labour forces has developed. Though most of the technologies are relatively easy to copy and inexpensive to acquire they have not diffused to all areas, which is explicable by the composition and costs of available resources and human skills.

Digitisations of production technologies and applications of electronic communication networks are subject to network externalities and positive feedback mechanisms in use. These conditions impact the developmental process of the technology, which is no longer subject to the individual businesses but to more general levels of application. Some of the results from networking externalities are that competing communication standards notably different CAD/CAM-files and EDI-standards have become compatible and transmittable through Internet-based structures. There are very few successful standardisation attempts within this industry and each nation or region apply its own measurements and sizes. Some success has however been evident for establishment of shared communication standards e.g. EDIFACT, EDITEX and for CAD/CAM-files, but further initiatives and results are still required.

As compared to the applied communication model outlined in chapter 2, there are some very evident overlaps. Most evident are the common basis of bounded rationality and focus on information

processes in enhancing knowledge levels. The model applies the 4 areas of business knowledge, which are thought assisted through communicative activities rooted in shared worldviews. Evolutionary economic theory is further applicable in analysing regional and national developments related to technological trajectories, but pays only little attention to the formation of value chains and identification processes of specific business partners. Another limitation of the evolutionary approach is its arms-length distance between organisational performances and the economic processes at markets. Notably the Darwinist approach based on blindfold mutations is unsuitable to analyse business integrations and market transformations from supply-push to demand-pull structures.

6.4. Costly Information

Transaction cost theory is another theoretical contribution on the analyses on the role of information in economics and on the impacts from applied ICTs. The core analytical unit of this approach is the transaction, which is embedded in some form of cost associated with information acquisition and handling. Whether it is in hierarchies or on markets: costs relate to searching and contracting[583]. Consequently this approach applies a different approach to information and acquisitions than the previously mentioned: information is costly and improved ICTs will change costs, and shift the barriers for information searches and contracting in all spheres and potentially shift barriers between firms and markets.

Transaction cost analysis is based on a contractual nexus where all the economic interaction can be perceived as formalised contractual relations that specify conditions and rewards. Implicit to the contractual nexus is that it is not possible to predict all possible events contracts cannot encompass all aspects, and hence become incomplete. Economic interactivity is embedded in continuous risks of mal-performances by the contracting parties e.g. "hold-up" problems[584], which leads to levels of potential economic losses.

Economic agents are conditioned by bounded rationality and opportunism, and technology by high assets specificity[585]. Whereas Coase relates transaction costs to entrepreneurial skills, Williamson relates the costs to personal characteristics and importantly the applied technology: The higher the

[583] Coase, Ronald (1937): "The nature of the firm", in Louis Putterman (ed.) (1986): "The economic nature of the firm", Cambridge University Press, pp. 72-85.
[584] Holmström, Bengt & John Roberts (1998): "The Boundaries to the Firm Revisited", in Journal of Economic Perspectives, Vol. 12, pp. 73-94.
[585] Williamson, Oliver (1986): "What is Transaction Cost Economics?", in Oliver Williamson: "Economic Organisation. Firms, Markets and Policy Control", New York University Press, pp. 174-191.

levels of bounded rationality and opportunism, the more likely it will be that agent pursuit own interests instead of contracted agreements. Transacting risks increase and thus the costs. And the more specific the assets the more are pair-wise coupling of parties important, and hence are vulnerability and transaction costs higher. High transaction risks are linked to high transaction costs, which impact the economic organisation of productions: make-or-buy.

Economic decision-making within this theoretical analysis follows the neo-classical mechanical optimisations however in a world of costly information: institutionalised rule-following that optimise performance is to choose governance-structure that minimises the combine costs of production and transacting. This leaves the decision-makers with choices of market purchases or internal provisions.

> "Transaction-cost economics concurs that the transaction is the basic unit of analysis and regards governance as the means by which order is accomplished in a relation in which potential conflict threatens to undo or upset opportunities to realise mutual gains." (Williamson, 1998[586]).

This stringent optimising rule relentlessly dictates the rational economic actions and has consequently been termed a functionalist rationality: functionalist institutions dictate rationality[587].

Crucial to choosing governance structure is to evaluating risks from different structures: risks cannot be predicted but decision-makers may have some expectations. Expectations indicates how to evaluate risks by different agents and governance structures, are rooted in historic events, and may become adaptive, subject to the evolutionary procedural rationality:

> In accordance with the functionalist mode of analysis, 'observed' ways of organising transactions are therefore explained by their 'beneficial consequences' that is, their ability to economise on transaction costs. Thus Williamson does not explain 'observed' governance structures as the result of a rational plan, intentions or design, but as the final result emerging from some unspecified evolutionary processes." (Knudsen, 1993[588]).

In the transaction environment there exists two separate and competing organisational forms: firms versus markets. Stereotypes of the firms relate to 'islands of conscious powers', where an entrepreneur bypasses the conventional price mechanisms and instead directs production activities. These islands emerge as some superior entrepreneurs emerge that are especially knowledgeable[589], or risk willing[590], and hold organisational powers to direct and optimise resources, which are difficult to specify and

[586] Williamson, Oliver (1998) "The Institutions of Governance", in American Economic Review, Vol. 88, pp. 75-79, p. 76.
[587] Op cit: Knudsen (1993).
[588] Op cit: Knudsen (1993), p. 283.
[589] Op cit: Coase (1937).
[590] Knight, Frank (1986): Risk, Uncertainty, and Profit", in Louis Putterman (ed.): "The economic nature of the firm", Cambridge University Press, pp. 61-65.

hence trade on markets e.g. labour. Raison d'être of firms are their organisational abilities to direct resources in flexible ways accomplished through few, loosely specified, long-term (employment) contracts. Production costs are higher within firms but transaction costs are much lower than at markets. Expansions of the firms will continuously strain the organising abilities of entrepreneurs, rising tasks and resources result in information overload and in diminishing marginal returns, rising transaction costs and preference for markets. Markets are the confronting alternative that has been stereotyped by short-term contracting and impersonal relations based on well-specified items and tasks. Transaction cost analysis is suitable in analysing organisational structures of either market or hierarchy, but is limited by inabilities to handle in-between organisational forms as relational markets and networking[591&592].

Information Searching

Transactions in the Coasean world are composed of two major processes: identification of true prices, and negotiation of contracts. Costs of price-identification may be decomposed into elements of information acquisition, information handling, subjected to the individual skills of the entrepreneurs. Dimensions of contract negotiation are likewise subjected to entrepreneurial abilities i.e. task-specifications, negotiation of conditions, and mediation. Businesses performances and abilities in this perspective hinge on the entrepreneurial and organisational structures, and hence firms differ in composition due to variations in resourcefulness: resource based perspective of firms is similar to the evolutionary approach, but contrary to the neo-classical production function[593].

Table 6.2: Coasean Transaction Costs and applied ICTs

	- Firms - Internal relations	**- Markets -** External relations
Searching	Management tools Accumulated knowledge Score cards	Browsing Trust Reputation
Contracting	Employment contracts Work-descriptions Surveillance Payments	Product standardisations Skills, Shared workspaces Monitering EFT, EDI, etc.

[591] Putterman, Louis (ed.) (1986): "The economic nature of the firm", Cambridge University Press, introduction, pp. 1-29.
[592] Powell, Walther (1990): "Neither Market nor Hierarchy", in Research in Organisational Behaviour, Vol. 12, pp. 295-336.
[593] Foss, Nicolai (ed.) (1997): "Resources, Firms, and Strategies", Oxford University Press, introduction, pp. 3-18.

Identifications of true prices are related to the skill and knowledge by the entrepreneur on employees' skills, productivity etc. both individually and in work-teams[594]. Through increasing abilities for distributed accesses and computerisation of work-tasks, the entrepreneur may gain additional knowledge on the individual performances. Technologies enable increased levels of information and hence lowered costs in acquisitions through surveillance of computer time, electronic communications etc. However, through the computerisation of work-tasks the complexity of data and information can accelerate whereby individual tasks and productivity levels get blurred.

Another major organisational gain from applying ICTs relates to computerisation of the entrepreneurial function itself: digitisation increases the information handling abilities. Through applied ICTs the entrepreneur is provided with analytical tools to manage and store crucial information on internal productivity levels. As the internal transaction costs are subjected to the entrepreneurial information skills, applications of ICTs may shift the levels of information analysis and marginal utility, limit bounds to rationality, and alter the threshold for deciding to integrate functions and thus alter firm boundaries.

In order to determine whether to make-or-buy it is required that entrepreneurs compare the internal production and transaction cost to the true prices at the marketplace. Price-information is gathered through browsing the markets: defined items condition the search for relevant suppliers and detection of prices.

It is possible to determine an optimal level of information searching. Costs of acquiring information are primarily composed of the time spend in searching, and the optimal search time will therefore be where expected gains from additional search time equal the costs of using more time[595]. The less fluctuating the collected information on prices, the less likely it will be that additional search time will reveal radically new, better information. Consequently the result of the entire information gathering process comes to rest with the outcome of the initial time spent in information acquisitions. Information searches are also marked by the abilities to define items: the less standardised the traceable items and services the more likely it is that searches will be complicated and time demanding.

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[594] Alchian, Armen & Harold Demsetz (1972): "Production, Information Costs, and Economic Organisation", in American Economic Review, Vol. 62, pp. 777-795.
[595] Stigler, George (1961): "The Economics of Information", in The Journal of Political Economy, Vol. 69, pp. 213-225.

Usage of specialised information services and ICTs impacts the entrepreneurial abilities to acquire information and the results from searches. Economy of scale in information gathering will benefit the establishment of specialised information providers: the more diverse the market, the more likely it is that specialised information brokers and services providers will develop[596]. Applications of ICTs and diffusions of uniform communication networks assist the specialised information brokers. Another marginalist approach to information gather comes to similar conclusions: utility of additional information is decreasing and costs in acquisitions are rising, hence will specialist information brokers be viable when they can specialise activities and lower costs in information acquisitions[597]. Electronic marketplaces and information brokerage are some of these service providers that are especially applicable in search for well-defined, standardised items and services. However, improving search tools and industry-wide XML-standards will also be helpful for the individual entrepreneur in conduction own searches.

Contracting

Embedded in the pricing information and cost determination is the potentials from unpredicted actions leading to transaction risks and economic costs: losses due to lower qualities, delayed delivery, finding other suppliers etc. To a certain degree these circumstances can be foreseen and incorporated into the contract, but due to bounded rationality of economic agents the contracts will be incomplete[598]. Contracting of agreements will have to deal with numerous aspects related to predictable events e.g. specification provisions, reward structures, but also account for discrepancies due to unforeseeable events, conflicts of interests etc.

Contracting is thought to encompass the processes of specifying, negotiating and fulfilling agreements[599]. In an optimal neo-classical economic world of full information all products and services would be well defined and contracts could easily be made: short-termed market relations will dominate and allow entrepreneurs to shop the markets for cheapest offers. However, not all items are applicable to up-front specifications and short-term contracting, indeed firms are characterised by organising input that is ill-suited for market transactions notably labour. Labour contracts get

[596] Op cit: Stigler (1961).
[597] Alba, Joseph et al (1997): ”Interactive Home Shopping: Consumer, Retailer, and Manufacturer Incentives to Participate in Electronic Marketplaces”, in Journal of Marketing, Vol. 61, pp. 38-53.
[598] Foss, Nicolai et al (1998): “The theory of the Firm”, available at www.cbs.dk/departments/finance/publikationer available June 2000, pp. 1-21.
[599] Op cit: Coase (1937), a more thorough discussion of contracting steps and issues has been offered in chapter 2 in the outline of the communication model.

complicated by inabilities to specify upfront which services or functions that will be required at what times, instead long-term contracts only specifies labour-time: entrepreneurs specify tasks during the contracting period.

Costs of contracting are related to the entire set of operations associated with specifications, negotiations and fulfilling conditions. However, as agents are restricted in information access and bounded in rationality there are numerous possible future unforeseeable events that lead to potential conflicts. Contracts have to define probable events and stipulate needed control and mediation mechanisms. Costs of contracting are conditioned by increased likelihood of conflicts in situations of high degrees of opportunism and bounded rationality – thought higher at markets than in firms. Risks and economic impacts from conflicts are also rising with levels of asset specificity[600]. Associated to the conflict and risk evaluation are issues of trustworthiness and frequency of interaction: the more trustworthy the agents, the lesser the uncertainty and fear for conflict, and consequently the lesser resources required in contract specifications, and likewise the more frequent the economic interactions the more probable it is to initiate post-contract reprisals and limit opportunistic behaviours[601&602].

In cases of complete contracting and with information asymmetry, there will also emerge potential conflicts and increased transacting costs[603]. Contracting will besides the specification issues also deal with incentive structures and control mechanisms that reduce the likelihood of misconduct. Agency costs denotes the resources connected to these issues, and have especially been applied in analyses of internal business organisation i.e. principal – agent theory. One issue of the information asymmetry has been to emphasise the need to monitor agents and making bonding arrangements or incitement structures that both reduce the likelihood of shirking and reduce the costs of surveillance: optimal business organisation is found in the junction between optimising productivities and minimising control costs[604]. A related issue is the metering problem of individual agents and free-rider problems when employed within teams, which is the prime organisational structure of firms[605].

[600] Op cit: Williamson (1986).
[601] Williamson, Oliver (1975): "Markets and Hierarchies: Analysis and Antitrust Implications", Collier Macmillan Publishers, London.
[602] Sabel, Charles & Jonathan Zeitlin (1997): "World of Possibilities", Cambridge University Press.
[603] Op cit: Foss et al (1998)
[604] Jensen, Michael & William Meckling (1986): "Theory of the firm: managerial behaviour, agency costs, and ownership structure", in Louis Putterman (ed.): "The economic nature of the firm", Cambridge University Press, pp. 209-229.
[605] Op cit: Alchian & Demsetz (1972).

Applied ICTs and DMM-technologies in the contracting process will assist the market and entrepreneurial functions differently and consequently impact the optimal firm size. Through enhanced information systems it becomes easier for the entrepreneur to collect and store information, and to specify contract issues: codification of items make product descriptions easy, EDI-based messages ease quantification and timing requirements, DMM-files enable visual presentations and descriptions of products and services etc. Negotiations may also be impacted by stored contracts for reuse, online legal services, communications of worldviews and trustworthiness through videoconferencing etc. Control mechanisms may also be enhanced through web-based monitoring, and codified production standards. Finally, the contract fulfilment is eased through transmissions of digitised products, provision of services, and funds transfer.

Electronic marketplaces are especially interesting for the transacting processes: brokerage functions assist the identifications of potential businesses and of true prices on markets, and contracting gets assisted by enhanced trustworthiness due to certifications, and mediation mechanisms for transportation and payments[606]. Generally electronic marketplaces will increase the transaction processes through extended reach and searches, and through enhanced effectiveness and trust[607].

Analysed ICTs and DMM-Technologies

Transaction cost analysis is in itself not concerned with the structures of technological development. Technological innovations only impact the economic sphere indirectly through transformation of asset specificities; ICT developments have more direct impact on information processing and costs. The theory offers no insight to structures of innovations nor is it based dynamic processes in economic optimisation:

> The economic problem, then, centres around combining given inputs and outputs in a way that minimises transaction costs, given technology. Innovation, the creation of markets, learning within and between firms etc. are either side-stepped or implicitly taken to be unimportant to economic organisation. (Foss, 1993[608]).

With its emphasis on the economic transactions: information processes of searching and contracting, it becomes possible to analyse the impacts from changed information processes on the economic activities. Impacts from developing ICTs and DMM-technologies relate to improved entrepreneurial

[606] Berryman, Kenneth et al (1998): "Electronic Commerce: Three emerging strategies", in The McKinsey Quarterly, Vol. 1, pp. 152-159.
[607] Kambil, Ajit et al (1999): "Transforming the Marketspace with All-in-One Markets", International Journal on Electronic Commerce, Vol. 3, pp. 11-28.
[608] Op cit: Foss (1993), p. 131.

abilities to search for information and specify contracts. The search processes are especially assisted by brokerage services and abilities to specify searches on industry-defined standards. Contracting issues are assisted through enhanced abilities to specify products, virtual presentations, negotiate conditions, distributed communications, monitoring and mediation of conflicts, and in transmission of some products, services and funds.

Electronic marketplaces are particularly interesting due to the brokerage functionality that assist extended information searches and more truthful determination of market prices. Additional services are included related to creation of trust, mediating transportation payment conditions, and provision of specialised information services etc

Transaction cost theory is applicable in analysis of electronic commerce and value chain structuring. Concerns deal with the enabling effects from applied ICTs that assist information sharing, brokerage and integration. On one side it has been argued that the extended reach of electronic networks, information processing and uniform codifications of items lead to enhanced brokerage effects, and eventually to extensive electronic markets[609&610]. Viability of electronic markets relate to the eased identification mechanisms, which enable purchase at lowest possible costs and more efficient resource allocation. On the other side it is argued that the enhanced information sharing effects first and foremost support integrating effects and supports value-added partnerships[611&612]. Within the value-added partnerships information gets exchanged and shared knowledge is formed, through which the businesses learn and develop their services and production skills. In-between there is a myriad of positions that stipulates the simultaneous occurrence of both structures e.g. “mixed mode operations” [613], or both the effects combined e.g. “move to the middle”[614 &615].

> "IOSs *[Inter-Organisational Systems, SH]* make all forms of governance structure more effective and efficient and do not alter substantially the relative costs of markets and hierarchies... Rather than a shift towards markets or hierarchies organisations are exploiting the

[609] Malone, Thomas et al (1987): “Electronic Markets and Electronic Hierarchies”, in Communications of the ACM, Vol. 30, pp. 484-497.
[610] Malone, Thomas et al (1989): “The Logics of Electronic Markets”, in Harvard Business Review, Vol. 67, pp. 166-172.
[611] Johnston, Russell & Paul Lawrence (1988): “Beyond Vertical Integration – the rise of the Value-adding Partnership”, in Harvard Business Review, Vol. 68, pp. 94-101.
[612] Johnston, Russell & Michael Vitale (1988): “Creating Competitive Advantage With Interorganizational Information Systems”, in MIS Quarterly, Vol. 12, pp. 153-165.
[613] Holland, Christopher & Geoff Lockett (1994): “Strategic Choice and Inter-Organisational Information Systems”, in Proceedings of the 27th Annual Hawaii International Conference on System Science, pp. 405-415.
[614] Bakos, Yannis & Eric Brynjolfsson (1993): “Why Information Technology Hasn’t Increased the Optimal Number of Suppliers”, in Proceedings of the 26th Annual Hawaii International Conference on System Science, pp. 799-808.
[615] Clemons, Eric & Sashidhar Reddi (1993): “Some Propositions Regarding the Role of Informaiton Technology in the Organisation of Economic Activity”, in Proceedings of the 26th Annual Hawaii International Conference on System Science, pp. 809-818.

> enabling effects of IOSs by operating mixed mode business relationships in which elements of both hierarchy and market are evident simultaneously." (Holland & Lockett, 1994[616]).

Middle positions enhance the dual effects, which get expressed in market-like functions for some purchases and more integrated qualitative partnerships for provision of other more crucial items. Combinations of the effects relate to creation of minor markets where a set of pre-qualified suppliers competes on some specified products and conditions.

Concepts of costly information in the transaction cost approach get applied in other fields than optimal governance structures and electronic marketplaces: physical capital and vertical integration, labour employment etc[617]. A very interesting string of analysis emphasises the consequences of costly information on the hierarchical business structures. Analysing the internal structures of businesses Williamson finds clear evidences for the preferability of M-formed organisations as compared to the U-formed[618]: within the multidivisional structures businesses can reorganise internally, provide better monitoring structures and internal marketplaces through which the internal transaction costs get reduced and internal competition and productivity increase. Similar lines of thought have been applied in analysis of decentralisation of decision-making and agency costs. The more distributed and decentralised the decision-making, the more difficult to monitor agents and the larger the impacts from interest conflicts: ICTs reduce communication costs and assist centralised decision-making, but will also reduce agency costs and support decentralisation processes[619]. Information processes may also impact the optimisation strategies and the firm-sizes through other means. Costly information will lead businesses to collect less information and organise accordingly, notably small businesses will find information processing costly and consequently apply simplistic structures based on autocratic decision-making suitable for environments with only a single volatility factor:

> "A single major source of volatility, theory shows, supports the very kind of autocratic management style that seems to be associated with small firms. Large firms, by contrast, tend to operate in relatively stable environments. More precisely, they operate in environments where there are multiple sources of volatility, but where no one source of volatility is sufficiently large to dominate the others." (Casson, 1996[620]).

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[616] Op cit: Holland & Lockett (1994), p. 414.
[617] James, Harvey (2000): "Annotated Bibliography on Transaction Cost Economics", available at http://uhavax.hartford.edu/~HJAMES February 2000, pp. 1-35.
[618] Op cit: Williamson (1975).
[619] Gurbaxani, Vijay & Seungjin Whang (1991): "The Impact of Information Systems on Organizations and Markets", in Communications at the ACM, Vol. 34, pp. 59-73.
[620] Casson, Mark (1996): "The Comparative Organisation of Large and Small Firms: An Information Cost Approach", in Small Business Economics, Vol. 8, pp. 329-345, p. 330.

It is less obvious how to conclude on the applications of ICTs, the impacts on the organisational structures and optimal sizes of firms. Communications and monitoring processes are assisted by ICTs, which support both centralisation and decentralisation strategies. Businesses experiencing single-factor volatility will probably gain relatively much from applying ICTs that support simplistic information processing of single factors e.g. EDI-messaging if the volatility relates to quantitative uncertainty. Applied DMM-technology may also be relevant, but due to the media-richness and enhanced communication abilities the large firms in multi-factor volatile markets are also set to gain.

Summary and Conclusions

Transaction cost economics analyse activities in a world of optimising, almost rational agents where there are some costs of acquiring information. Transaction costs denotes the costs of searching and contracting, which engulf all economic activities both within firms and at markets. Theoretical predictions state that optimal governance structures should be located at the flux between minimised production costs and transaction costs.

This analytical approach has caught much attention especially in relation to the developing ICTs that impact the costs of information searches and contracting. Changed information costs internally and at markets impact the optimal firm sizes and interactions with markets. These considerations also apply to analysis of the textile and clothing industry where applications of electronic networking technologies have impacted decision-making on make-or-buy. Some of the most evident impacts from applications of these technologies relate to enhanced information brokerage at markets, product visualisations, specifications and developments through shared virtual spaces, and codification of items through barcodes and EDI-standards, which enable new levels of business interactions. Information brokerage, production specifications, and improved monitoring and communication tools assist internal and notably external information processes reducing the transaction costs at markets and imply increasing levels of outsourcing.

ICTs have become widely applied within the Danish textile and clothing industry, and hence they have impacted the industrial activities, which can assist in explaining the networking and value chain structures. Decisive to this analysis is the communication structures embedded in different electronic networks: different information networks enable different structures to search for information. EDI-messaging and electronic networks have been emphasised as factors that directs the search and commercial processes, which also have some foundation in the Danish case: when businesses utilise the same EDI-standards and networks they increasingly place orders within these structures. Above

analysis provides argumentation for rising costs of trading outside these networks and diminishing costs inside. These findings are supported by the industrial case, where appropriations of specific EDI-standards and barcoding have been prerequisite for manufacturers to supply major retail chains. Coasean information needs and Stigler's information processes are also applicable in arguing for geographical networking structures, where districts may be seen as the optimised search area: through periods of successful information searching the search processes will get confined to the district. This suggests that the industrial district of Herning-Ikast has emerged more by chance than by developments of skills or by a special resourcefulness.

Extensive industrial networking connected through electronic structures is evident to the case, which can be argued in the light of transaction costs: contracting through enhanced trustworthiness and lowered contracting costs. Businesses within expensive proprietary information networks, which have characterised the EDI-structures in this industry, have special good reasons for behaving well and to limit opportunism: failures will lead to fewer orders mediated through the network, and hence lead to waste of the resources put into the network. However, with the general improvements of the networking structures and lowering of information costs, these incentives will probably diminish. Another forceful line of argumentation relating applied ICTs with enhanced networking levels are the abilities to give information feedback and for businesses to upgrade their skills. Evidences from the Danish case are supportive on these accounts where CAD/CAM-technologies have improved business integrations and lifted quality levels. However, a primary accomplishment of applied ICTs in this case relates to speedier processes, which are not treatable within this analysis.

Besides argumentations for the networking organisational structures in-between firms and markets, the theory also enables analyses and predictions of value chains restructuring. The case has revealed three components of the restructuring processes, which are explicable by the transaction cost analysis. One element of restructuring relate to inclusion of new businesses and geographical areas in the production processes. Improved information searches based on the extensive reach of the Internet, search engines, industry-wide XML-codes, specialised information providers etc. all contribute to identify true price levels and new potential business partners. These tools have emerged in parallel to established information processes of fashion shows and fairs, trading companies etc., and offer new modes of reaching markets and for restructuring of value chains. Degrees of bounded rationality and opportunism, and hence transaction risks get reduced through brokerage services that also induce trust and through distributed communication structures: electronic marketplaces, Internet-based presentations of business profile, communications of shared worldviews through videoconferencing,

and distributed control mechanisms. Increasingly the applied ICTs and DMM-technologies reduce transaction costs at markets, distributed structures and become supportive in global chain structures.

Another element of the value chain restructuring is found with the movement of tasks from one agent to another within value chains. To the individual business this equals questions of making or buying, where the purchase will be from special trusted or dependant partners, and hence will this support argumentations for increased levels of integration. Transfers of tasks get enabled through improved information and communication structures that reduce the transaction costs and enable that tasks get placed at the most efficient and specialised business. There are ample evidences for increasing levels of integration and for the transfer of tasks from one partner to the next in the value chain. Sales functions have in some cases become transferred from retail sector to manufacturers, and the fabric acquisitions, storage and cutting have increasingly been transferred from Danish manufacturers to foreign subcontractors etc.

A final element of analysis of value chain restructuring is the development and inclusion of new specialised businesses. With improving information processes the transaction costs from purchasing on the markets will diminish, and new suppliers will hence emerge. This provides arguments for redistribution of tasks and development of new business models e.g. specialised service providers, specialised retailers or sales agencies etc. Companies that hold special competitive advantages related to costs, quality, timeliness, location, product or market knowledge etc. will hence become more viable to buy services and products from. Some of the specialised provides could relate to outsourcing of designing, to outsourcing of sales and storages to new agencies in other countries or for new markets, or to acquire fashion or market analyses from specialised agents, all of which are evident to the case. This also indicates increasing levels of business specialisation and small sized companies, which is quite evident for the Danish industry.

As compared to the applied model presented in chapter 2, there are obvious similarities related to the perception of agents and bounded rationality, costs of information and importance of contracting and trust issues. Whereas transaction cost analysis relates trust to opportunistic behaviours and bounded rationality impacted by repetitive economic interactions, the model prescribes a proactive approach where trustworthiness can be established through communication of worldviews. Another major difference between the analytical approaches is that the model relates bounded rationality to limited knowledge of what to do and to purchase, which is not the case in transaction analysis: in the model businesses have to communicate needs and possibilities, whereas transaction analysis prescribes full

knowledge and sovereignty by the entrepreneur. Needless to say, the transaction cost analysis applies a contractual perception of economic interactions: suppliers are identified, and conditions specified. Economic interactions are basically a-historic, there is no knowledge prior or after the contractual stages: post-contractual stages of learning and information feedbacks are incompatible. This has been modified in the 3-phased contractual processes in the proposed model. Finally, differences also apply to the static flavour of transaction cost analysis contra the dynamic approach of the model based on learning processes and procedural rationalities.

6.5. Industrial Economics

This section contributes with analyses of industrial economics. Industrial economics is a quite diverse concept and includes a wide span of economic analysis with quite different approaches. This concept covers analysis of product and firm specific characteristics, which conditions the performances of individual businesses and value chain structuring[621]. These concepts have been analysed in the previous chapter on value chain structures and will only attract indirect attentions in this section. Other parts of the analysis, which is dealt with more thoroughly below, are local specific and national specific characteristics that condition the economic performances of businesses within certain areas. Specific conditions that are thought especially relevant are localised resources, labour markets, infrastructures, competition and cooperation, social relations, institutions and technologies.

Local Specific Advantages and Industrial Districts

Analysis of local economic conditions have caught special attention due to exceptional performances of some geographical areas, where the good performances have been traceable to special specific provisions and organisational structures. Marshall's notions of competitions and market dynamics have been inspiring to the analyses of these localised economic activities[622]. Local specific advantages in support for economic competition have been related to resources and conditions that assist formations of clusters[623]. Within clusters there are good economic conditions for establishments of firms, which results in high birth rates of firms in the area and many businesses moving to the area. Increasing levels of competition within the area continuously force businesses to develop products, improve performances, and productivity levels. Related to the analysis of clustering is analysis of

[621] Porter, Michael (1980): "Competitive Strategy – Techniques for Analyzing Industries and Competitors", Free Press, New York.
[622] Zeitlin, Jonathan (1992): "Industrial districts and local economic regeneration: Overview and comment", in Frank Pyke & Werner Sengenberger (eds.): " Industrial districts and local economic regeneration", International Institute for Labour Studies, Geneva, pp. 279-294.
[623] Porter, Michael (1998): "Clusters and the New Economy of Competition", in Harvard Business Review, Vol. 76, pp. 77-91.

industrial districts, which instead of high-level competition highlights the district-wide levels of cooperation, financial and political institutions and importantly the social structures[624]. Through socialisation and informal networks the district-based businesses continuously interact with other businesses, which results in improved learning structures and outsourcing abilities[625]. In addition to the unique regional provisions and social structures, regionalism can also be argued on the basis of extended information flows and control mechanisms[626], which is elaborated upon after the outlines of clustering and industrial districts below.

Clusters

Clustering of firms has been related to abundance of localised resources, unique infrastructures, proximity of markets etc., which all contributes to generating economic externalities. These externalities make it particularly interesting for businesses of a particular industry to get located in the area:

> "Untangling the paradox of location in a global economy reveals a number of key insights about how companies continually create competitive advantage. What happens *inside* companies is important, but clusters reveal that the immediate business environment *outside* companies plays a vital role as well. This role of location has been long overlooked..." (Porter, 1998[627]).

Through the rising number of businesses located in the cluster, levels of competition accelerates, which continuously compel businesses to innovate, increase productivity levels and seek new business formations. These features get enabled through better access to employees and suppliers, specialized information, institutions and public goods. Position within the cluster also indicates levels of sincerity and trustworthiness: networking and outsourcing structures are supported due to the enhanced local skills and levels of trust.

Abundant local provisions of resources and exceptional conditions for production are no guarantee that clusters will emerge. The good localised conditions are arguments for businesses moving to the region and for new businesses to emerge, but also for gains related to economy of scale. If the economics of scale are dominating, the organisational developments will probably result in development of a single or very few dominating businesses. Or related to an ecological framework, the birth rate of businesses

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[624] Sengenberger, Werner & Frank Pyke (1992): ”Industrial districts and local economic regeneration: Research and policy issues”, in Frank Pyke & Werner Sengenberger (eds.): ” Industrial districts and local economic regeneration”, International Institute for Labour Studies, Geneva, pp. 3-29.
[625] Piore, Michael & Charles Sabel (1984): ”The Second Industrial Divide”, Basic Books, USA.
[626] McGovern, Siobhain & Zeine Mottiar (1997): ”Co-operative Competition: A Foucauldian Perspective”, in DCUBS Research Papers, Vol. 20, available at: www.dcu.ie/business/research_papers February 2000, pp. 1-13.
[627] Op cit: Porter (1998), p. 78.

have to be higher than the mortality if the regional advantages shall result in regional clusters or industrial districts[628].

Industrial Districts

Analyses of the industrial districts tend to be descriptive and highlights the key characteristics found: emphasis is not on the features that generate the local economic developments, but on descriptions of existing characteristics that mark present structures. Basic characteristics of districts are the simultaneous existence of many small and medium sized firms within a given industry. Firms of the district encompass all functions required by the industry: all production steps may be performed locally. This highlights both the districts independence of the outside world and the mutual dependence inside. Success of districts depends on the performances of all the minor businesses, no major enterprise dominates the local structures: individual businesses will emerge and wither away, but districts remain. Combined with the technological developments that enable flexible specialisation and small-batch production processes, it has even been stated that:

> "All of this technological flexibility allowed a firm that had guessed wrong about this year's fashion to serve as a subcontractor for a luckier competitor that had an overflow of orders; and next year the roles might very well be reversed." (Piore & Sabel, 1984[629]).

Some of the regional key factors behind industrial districts are the existence of many small firms, simultaneous conditions of market and non-market exchanges, cultural and social structures, and a mix of public and private institutions[630&631]. Existence of many small firms enable that functions easily can get outsourced to specialist businesses, which enable that overheads are kept low, and that high levels of flexibility are induced. Some exchange relations are based on conventional price and cost issues, but substantial parts of the exchanges are founded in other mechanisms related to networking and social relations. It has been argued that district-based labour markets are exceptional due to high quality levels, high rates of mobility, labourers as carriers of knowledge, and employment relations as cultivation of social relations, which assist the learning and sustainability of the district. And the political and societal interactions are also unique: specialised information institutions, cooperation, social and political commitment etc. Whereas little attention has been offered on the factors that

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[628] Staber, Udo (1998): "Inter-firm co-operation and competition in industrial districts", in Organization Studies, Vol. 19, pp. 701-724.
[629] Op cit: Piore & Sabel (1984), p. 215.
[630] Rabellotti, Roberta (1995); "Is there an 'Industrial District Model'? Footwear Districts in Italy and Mexico Compared", in World Development, vol. 23, pp. 29-41.
[631] Op cit: Sengenberger & Pyke (1992).

conditioned the emergence of industrial districts, more attention has been devoted to the developmental processes and conditions that make districts sustainable[632&633].

Industrial district is more than cluster a unique economic phenomenon: business relations are not determined by conventional economic considerations. Businesses get networked based on cost and quality issues as well as social relations. Personalised ties are generally overlooked in economic theory[634], but have caught special attention in the analysis of industrial districts and flexible specialisation[635]. Social relations and personal networks are decisive for much economic decision-making. Personalised ties more than short-term economic cost considerations direct the flow of orders. Indeed, businesses choose their business partners based on compliance with their business strategies: agents do not maximise rather they strategize[636]. Under specific circumstances the decision-maker's choices of strategies not only impact the future competitiveness of the individual business, but also impact the surrounding environment. Through the decisions made by a minor group of socially connected business managers, the future direction of a local industrial district gets shaped.

An important aspect of the personalised ties is that these ties offer higher levels of trust. Trust is a behavioural entity that makes human activities predictable, and is believed to be particularly evident in situations of abundant information levels, either through personal relations or through applied information networks[637]. High levels of information and trust will reduce risks from mal-performances by partners, and firms will acknowledge the wants and preferences of its business partners and react to unforeseen situations in order to optimise the outcome for the relationship, not only for the individual firm. Industrial districts have emerged as areas where trust levels are found to be exceptionally high: "the burden of experience and reflection is that trust can be found, but never created"[638].

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[632] Op cit: Best (1996).
[633] Corò, Giancarlo & Roberto Grandinetti (1999): "Evolutionary Patterns of Italian Industrial Districts", in Human Systems Management, Vol. 18, pp. 117-130.
[634] Granovetter, Mark (1985): "Economic Action and Social Structure: The Problem of Embeddedness", in American Journal of Sociology, Vol. 91, pp. 481-510.
[635] Op cit: Piore & Sabel (1984).
[636] Op cit: Sabel & Zeitlin (1997).
[637] Ebers, Mark (1999): "Explaining Inter-Organizational Network Formation", in Mark Ebers (ed.): "The Formation of Inter-Organizational Networks", Oxford University Press, pp. 3-40.
[638] Sabel, Charles (1992): "Studied trust: Building new forms of co-operation in a volatile economy", in Frank Pyke & Werner Sengenberger (eds.): " Industrial districts and local economic regeneration", International Institute for Labour Studies, Geneva, pp. 215-250.

Information

Regionalism may also be argued on the basis of unique information structures. As indicated above in the analysis of transaction cost economics, information processes have important roles in identifications of the true prices at markets, and that these information processes are costly. If the initial search procedures provide satisfactory results, there are very low incentives for additional searches. Transferred to a localisation aspect, information about local suppliers' qualities and prices is either known or easily extractable, whereas information on more distant suppliers is more costly to obtain. As long as the local suppliers offer satisfactory conditions, there are no incentives to search for more distant suppliers. An element that makes long distance communications costly is the need to establish trustworthiness and shared worldview, which requires media-rich communication structures notable face-to-face meetings. Alternatively, with increasing applications of DMM-technologies, this information barrier can be surpassed.

Information structures and communication abilities have indeed been recognised as important to the operations of industrial districts and of production organisers. Districts are based on unique communication structures, and businesses and employees speak their own unique language[639]: there exists cultural knowledge embedded in the specific language. Languages are dynamic structures that encompass knowledge from the past as well as knowledge from the present. It's much easier and less costly to communicate within a district where a similar language is applied than outside. Application of a mutual language would hence lower the costs of contract specifications and doing business. Production organisers hence hold competitive advantages related to information sharing and communications if they structure value chains inside the district they belong to[640]. Ideas about unifying languages that smoothen business processes have also been related to networks that are not united in culture or geography but in technology i.e. mutual EDI-standards[641].

Cultural structures are embedded in localised languages, which provide special conditions for information sharing and communication. Another interpretation of information sharing and formation of trusted relationships are found in the enhanced abilities to monitor and control others' activities. A crucial element of this Foucaldian analysis is that everybody feels that they get monitored and fear to

[639] Op cit: Rullani & Zanfei (1988).
[640] Kumar, Kuldeep et al (1998): "The Merchant of Prato revisited: toward a third rationality of information systems", in management Information Systems Quarterly, Vol. 22, pp. 199-226.
[641] Brousseau, Eric (1994): "EDI and inter-firm relationships: towards a standardization of coordination processes?", in Information Economics and Policy, Vol. 6, pp. 319-347.

be revealed as non-compliant[642]. Businesses within the district know they get monitored and will accordingly behave: the better the monitoring and communication structures the more evident the fear. Firms of a district will never know by whom or when they are monitored, and thus constantly expect to be monitored. As long as firms expect to be monitored, they will behave as if they did, and thus stride to perform accordingly.

> "For Foucault, power determines individuals' behaviour not by coercion but rather by controlling individuals' decisions to behave." (McGovern & Mottiar, 1997[643]).

In the Foucauldian perspective businesses feel that they are monitored even though there are no visible observer, nor a powerful agent that determines the rules of conduct. Some regionalised industries show similar trends of compliance if there are large, dominating regional players[644].

National Specific Advantages and International Trade

Besides the firm and local specific characters there is a range of national specific conditions that impact the competitive advantages of nations. International trade can to a large extent be interpreted as proves for existence of different national characteristics. Classical economic theory perceived this international trade as related to differences in national factor endowments and consequently different relative prices. Related is the idea of technology gaps where the technologically endowed country holds comparative advantages in capital-intensive products.

Later theoretical analyses e.g. the Heckscher-Ohlin-Samuelson theory, has emphasised that capital and technologies in contrast to labour are highly mobile factors[645]. International trade within this theoretical construction is instead of technology gaps based on an unequal distribution of immobile production factors, which determine the relative levels of productivity and prices. Through analysis of competition at the industry level instead of the national levels, this theory can be applied in explaining trade between countries with equal factor endowments. Trade between countries with equal factor endowments develops as nations choose to target resource in different industries in which they gain specialisation advantages, economy of scale and comparative advantage. Equal national factor endowments can result in different industrial competitiveness and hence trade between nations with equal factor endowments will develop:

> "An HO-type *(Hechsher-Ohlin, SH)* of model suggests that convergence in aggregate capital-labour ratios should be accompanied by convergence in the trade patterns of these

[642] Fine, Bob (1986): "Democracy and the Rule of Law", Pluto Press, London.
[643] Op cit: McGovern & Mottiar (1997), p. 4.
[644] Op cit: Corò & Grandinetti (1999).
[645] Fagerberg, Jan et al. (eds.): "Technology and International Trade", Edward Elgar, Cheltenham, UK, Preface.

> countries. On the other hand, our research on convergence of aggregate TFP (Total Factor Productivity) suggests that this convergence may be the result of different countries developing relative high levels of TFP in different industries. In that case there may be growing *divergence* of trade patterns as different countries increasingly concentrate production and exports in different industries." (Wolff, 1997[646]).

This theoretical approach may be criticised for being too optimistic about capital movements and technology transfers. In consequence new growth theory emphasises both national factor endowments and technological differences that lead to specialisation gains or economy of scale[647]. Instead of focus on competitiveness of nations one should concentrate on individual industries and identify the local factors that shape their comparative advantages and international competitiveness[648]. Competitive advantages of nations and industries rest with their location specific endowments as raw materials, labour force, financial access and infrastructure, but are also impacted by the ability to develop entry barriers, technological innovations, strategic alliances etc. An essential competitive factor is the technological developments that lead to economy of scale, entry barriers and first-mover advantages i.e. theoretical understanding of international trade have re-emphasised the technology-gap introduced by Ricardo.

These trade theories have concentrated on the economic structures related to technology and capital movements, and the relative factor compositions. Implicit in these contributions are that information flow freely and that markets are by and large running perfectly i.e. the only costs associated with international trade are related to transportation and the supplier that offers the cheapest or best products will gain. But this disregards that information gaps and transaction costs lead to market failures[649]. The more international or global the competitive environment the more likely it is that opportunistic behaviours exist and the less likely it is that the risks from misconduct can be avoided, which suggest that hierarchies will be a preferred organisational structure. Hence, some form of incompleteness is unavoidable, which lead to market failures and trade opportunities. Besides the transaction perspective, the formation of strategic alliances and inter-organisational cooperation also direct the international trade in this perspective.

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[646] Wolff, Edward (1997): "Productivity growth and shifting comparative advantage on the industry level", in Jan Fagerberg et al. (eds.): "Technology and International Trade", Edward Elgar, Cheltenham, UK, pp. 1-19.
[647] "Globaliseringens årsager og konsekvenser" (1999) (The Causes and Consequences from Globalisation), HTS Kartellet, available at www.hts.dk/pjecer, January 2000, pp. 1-74.
[648] Porter, Michael (1990): "The Competitive Advantages of Nations", Free Press, New York.
[649] Op cit: "Globaliseringens årsager og konsekvenser" (1999).

Analysed ICTs and DMM-Technologies

Danish textile and clothing industry contains many of the key characteristics identified in the above theoretical contributions: many small and medium sized firms located in a geographically distinct area with high levels of networking. Clusters and industrial districts emphasise the existence of localised factors and trust relations but pay little respect to the roles of information and applied ICTs. Whereas information has no direct impact on district structures in orthodox theory on clusters and industrial districts, the technological developments do. Through the unique interactions amongst the regional firms there are both high levels of competition that compels businesses to apply latest technologies, and a good labour force and regional institutions that assist information sharing and knowledge about technological innovations.

However, information access and processes can have more direct roles to play either in localised languages that smoothens regionalised business interactions, or as the information associated with the powers of surveillance. ICTs and structured information sharing e.g. based on regional or industry-wide communication standards and EDI are supportive in generating local languages that assist commercial interactions. Shared EDI-structures impact much more than just the exchange of information: through shared standards the information processes will converge and business interaction will ease[650]. Applications of ICTs are also important in the Foucaldian surveillance perspective related to information sharing and reputation shaping. Within this perspective information access and sharing is more related to distributed monitoring tools as web-cameras, and the information spreading tools e.g. the Internet, homepages and online information services.

Information and information access is also relevant to the international trade, notably in the interpretation of information gaps. Businesses that hold superior information accesses will be better positioned to identify commercial opportunities and make profits. Through globalisation of information processes the identification processes and trade will increasingly become internationalised, which evidently has been supported by data from the globalised textile and clothing industry. The role of market information has also been revealed in the tighter relationships between manufacturers and retail, and in the establishment of alliances with trading companies abroad that hold special knowledge about local markets.

650 Op cit: Brousseau (1994).

Summary and Conclusions

In this section it has been revealed how trade amongst businesses not only relates to firm specific advantages, but that both regional and national conditions are influential. These theoretical considerations have solid foundation in the presented case: especially when it comes to regional conditions, the Danish textile and clothing industry has frequently been analysed as an industrial district. And when it comes to international outsourcing there are ample evidences for differences in national factor-endowments and relative prices. Value chains get structured across districts and national boundaries to reap the advantages related to increased efficiencies, capabilities and from international division of labour. Important prerequisite to obtain these advantages are not only the cost differences and different skill-levels but also the business partners can be trusted, reducing the risks from transaction. Trustworthiness has been associated with both regionalised personal relations and information sharing processes.

The Herning-Ikast industrial area holds many characteristics that resemble the key-features of clusters and industrial districts: initially abundant labour, raw materials and energy supply, good infrastructures and proximity to continental markets. These good conditions have impacted that many businesses have moved to the area, which is dominated by many small and medium sized companies. Competitive levels are high and regional businesses continuously seek to innovate and optimise productions: applications of ICTs and DMM-technologies are one means to obtain competitive advantages. In the realm of industrial district theory there are also high levels of cooperation, which is also evident within the region: specialised information institutions exists and businesses cooperate in sharing knowledge and experiences about new ICTs and DMM-technologies through informal structures. Personalised structures are evident, and trustworthiness of business partners is often mentioned as a prerequisite to doing businesses.

Within the orthodox theories on clusters and industrial districts, information is diffused through the mobile labour force and informal relations. Applied ICTs will only have little impact due to the enhanced personalised communication abilities found in the DMM-technologies. Another aspect of information is founded in the dissimilation of information in a shared language and in improved monitoring and surveillances. The abundance of personalised informal relations makes information travel easily within a region, and information about a business' misconduct will quickly spread: in order to maintain reputation a business have to behave according to locally prescribed rules of conduct, and trustworthiness will hence develop. Industrial districts are mentioned as particularly trustworthy structures based on personal relations, but recognising the role of information sharing, the

improving ICTs and DMM-technologies and their distributed character may result in similar high levels of trustworthiness outside districts: abilities to communicate shared worldviews without physical meetings may shifts the boundaries for trusted structures.

Different national characteristics are also important to the trade within this industry. Differences in national factor endowments impact the viability of international division of labour e.g. the international outsourcing of labour intensive functions. As the Danish industry has been subjected to rising wage-levels dual processes have been pursued: product differentiations based on higher quality and capital investments, and cost minimisation through outsourcing of labour intensive functions. The international trade rooted in cost differences bare resemblance to the classical technology gap approach, where differences in factor endowments impact the relative prices and comparative advantages. The case also points to the upgrading of regional industries notably the Portuguese: competitive advantages emerge in cost advantages, but gradually the skills are upgraded and regional competitiveness shifts towards higher quality provisions at higher costs. This is associated with changes in competitive strategies towards product differentiations: indeed substantial parts of global textile and clothing trade are founded in trade between Western European countries with roughly equal factor endowments. The diminishing importance of intra-European trade and rising importance of Asian-European trade should not be seen as a reducing importance of high-quality products, but rather as the result of continuously improved production qualities of the Asian textiles and improved communication structures that speeds up provisions. This inter-regional trade also points to the increasing global levels of information and abilities to identify business opportunities on other continents: information gaps get reduced through applied ICTs.

As compared to the introduced model in chapter 2, there are only minor overlaps. These approaches to industrial economics are based on regional and national characteristics and pay lesser respect to firm specific advantages and to the role of ICTs and information. However, there are some similarities e.g. in the information-based approach to regional advantages: information processes are crucial in communicating worldviews and establishing trust. With improved distributed communication and monitoring abilities the trustworthiness as a localised factor may wither away, but other regional provisions e.g. the labour market remains.

6.6. Conclusions

A focal issue of this thesis has been the investigation of economic activities in a manufacturing industry, which increasingly has become exposed to altered competitions and communication-abilities. Analyses of the industry-case indicate different needs to share information and to communicate. These needs have been related to different knowledge-forms required at different stages of the economic processes. It has been concluded that communications and interactive processes are important for generating shared worldviews, trust, display skills, and for shared product-developments. Information sharing is also important in its support for value chain operations, information on prices, qualities, capacities etc. As the industrial markets alter, so do the competitive environment and communication-needs. Speedier market-changes and customer-segmentations compel businesses to offer smaller and more flexible production-lots that satisfy the current demands. Industrial value chains increasingly alter from supply-pushed towards demand-pulled, which require that the industry accesses and integrates information about consumer-preferences.

This chapter has offered analyses of some economic theories that have been applied in describing the economic activities in the Danish textile and clothing industry, and the developing ICTs and DMM-technologies. Analyses of the economic theories include information theory of the New Economy, institutional economics: evolutionary and transaction costs, and industrial economics. These analyses of the theories relate to identification and discussion of their core statements and core processes, which have enabled an analytical investigation of information and communication in these theories. Individually these theories contribute with important but only partial insight into the operations and structures of the industry, and into the applications of ICTs. Indeed the applied model throughout this doctoral thesis has been heavily inspired by these 4 approaches as well as communicative theories.

Information analysis of the New Economy emphases the increasing transmittability of information enabled by increasing reach and capacities of the applied telecommunication networks. Three aspects have been identified as particularly relevant to the analysed industry: expanding reach of ICTs and converging communication structures, economy of scale in information services suggesting economic viability of specialised providers, and thirdly enhanced information levels generated through shared ICT-structures. These points are forceful in explaining the functionalities of ICTs and the activities in information-based service sectors, but seem less applicable for a manufacturing industry. This theoretical contribution seems to be too optimistic about the displacement of the physical world and transition-processes into digitised spheres: substantial parts of the value chain operations of

manufacturing industries still relate to belabouring of physical items subjected to the rules from the "old economy". With further developments of the ICTs and DMM-technologies, some of the predicted trends may become more outspoken: increasing levels of digitisation of production, globalisation of services, and more personalised provisions. Though the information-processes increasingly get separable from the physical production-processes and hence possibly subjected to commercialisation by specialised service providers, the presented case instead emphasises the role of information integration in support for decision-making. ICTs get applied to integrate value chains operations not so much to acquire specialised information services from third parties.

Evolutionary economics perceive businesses as biological entities where the genes are organisational routines and where markets act as selection mechanisms. Businesses just as individuals are marked by their bounded rationality and must apply rule-following institutions on how to produce, invest and innovate. Information-processes are important: limiting the bounds to rationality, internal information-loops upgrade resources to core capabilities, and external information-loops inform about market-performances and demands. Path-dependent technological trajectories impact the developments of production-technologies, and network-externalities are impacting the communication-networks and standardisation-processes. Evolutionary processes are powerful in explaining the gradual developments of technologies and businesses, which indicate specialisation-processes and gradual applications of ICTs and DMM-technologies. However, it seems less applicable in dealing with more revolutionary transformations and paradigmatic shifts e.g. the new business models on information services, or the more fundamental market-transitions from supply-push to demand-pull. The presented case has ample indicators for gradual developments related to technologies, individual businesses, regions and nations, but also contains some more substantial transformations related to shifts in value chain structures, which are not easily linked to evolutionary processes. The evolutionary analysis notably in its Darwinist approach has an arms-length distance to economic mechanisms and to the costs of information, which have been modified in the presented model. The model incorporates the processes of knowledge formation into a transaction environment.

Transaction cost analyses deal with information-acquisitions and communication-abilities, which are impacted directly by applied ICTs and DMM-technologies. ICTs are supportive for identification of true prices both internally and externally, and DMM-technologies also assist product-specifications, and monitoring processes. Especially the contracting-issues are assisted through these means as skills and conditions are communicated, and visual product specifications are assisted. This transaction cost analysis is forceful in its perception of costly information-processes and limited acquisitions. The

subsequent bounded rationality is however somewhat static or procedural: the entrepreneurs do not learn or develop, they just adapt. Transaction cost analysis prescribes optimal governance structures on the basis of production and transaction costs, decided by the knowledgeable entrepreneurs that know what to produce. Both the case and the applied model suggest that the bounded rationality impacts the knowledge-level of the entrepreneurs that do not automatically know what to produce: information sharing and shared knowledge-formations are essential, but incompatible with the transaction cost analysis. Hence, the applied model suggests a 3-phased contractual model where worldviews and trust can be communicated before contracting and information sharing and learning are enabled in post-contractual communications. Through communication of worldviews and trustworthiness to agents outside the business-boundaries the applied model seems preferable to the transaction cost analysis, as it hence is applicable in describing long-term relations between different businesses, which are neither market nor hierarchy.

In addition to the firm-specific resources as capital, employees and organisational structures there are some regional and national specific characteristics that impact the competitive advantage of individual businesses. Industrial districts and clusters emphasise the regional structures of competition and cooperation, which are also evident for the Danish textile and clothing industry. Likewise there are national differences that impact the international division of labour and the extensive outsourcing structures. These approaches provide interesting additional analytical powers but cannot stand alone in analyses of value chain structures and applied ICTs, notably as ICTs and DMM-technologies enable communication-structures at a global scale. Information is only though marginally relevant in the orthodox district-analysis where information-processes are granted little, indirect impact on developmental structures and patterns of interaction. Information-processes are however evident in the language and surveillance perspectives, and in the analysis of information gaps at a national scale. Applied ICTs and DMM-technologies hold the potential to impact all these components pointing to receding importance of geographical locations.

Chapter 7: Conclusions

7.1. Communications in Economics

7.2. Information Needs and Provisions

7.3. Impacts from Applied DMM-Technologies

This doctoral research has been founded in iterative research-processes through which hypotheses have been posed and subsequently verified in order to reach the research-questions pursued throughout this thesis. These processes have led to a continuous interaction between research-questions, data-collection and analyses. A set of research-questions has been formulated that capture the industrial and technological developments and their socio-economic impact. In analysing these questions a communication model has been constructed. This model has been constructed and introduced, as none of the analysed theoretical analyses seem to encompass all the relevant aspects of the industrial case. Through the doctoral research-processes it has become evident that the economic theories only provide partial insight and applicability in dealing with the characteristics of the case, and thus a need for an alternative approach has been established. The introduced model enables analyses of the industrial information and communication-needs, just as it has been possible to analyse the impacts from applied ICTs and DMM-technologies. The analytical necessity of this communication model relates to its enhanced abilities to analyse the industrial activities encompassing both the physical and virtual worlds, and its abilities to combine strict economic reasoning and cost considerations with other aspects like learning and social environments. A more thorough outline of the model's abilities to deal with the posed questions is presented below.

Central to the academic analyses and introduction of the communication model are the theoretical shortcoming in describing actual market-performances in the light of improved ICTs and DMM-technologies. Theory prescribes full information and perfect markets, but evidences show frequent sales and items out-of-stock within the textile and clothing industry. The case-analyses reveal that personal communication is essential in establishing trust, show skills and commitments. Information and communication is also evident for the value chain operations as designs and orders are distributed amongst the business-partners. Both information sharing and personalised communications are important aspects in the running of production-processes and some communication-structures have been identified for the conventional supply-push structures. However, the textile and clothing industry increasingly get subjected to international competitions and market segmentations, which compel businesses to supply small production-lots through speedy production-cycles. This implies an enhanced responsiveness to market-demands, and gradually the markets alter from supply-pushed to demand-pulled structures. These alterations impact the industrial organisations and applications of ICTs and DMM-technologies are thought especially helpful.

ICTs such as e-mail and EDI-massages and DMM-technologies as CAD/CAM have become well-established information tools in this industry. But, as DMM-technologies develop there emerge

increasing abilities to operate in virtual environments, which surely will impact the established value chains. Some of the most important aspects of emerging DMM-technologies are the abilities to generate virtual workspaces, virtual meeting-rooms, and generally better searches and information sharing. The virtual workspaces enable interaction on product-developments and a better responsiveness to market-demands. Virtual meeting-rooms enable personal meetings irrespective of physical location. These meetings are thought essential for establishing worldviews and trust, which precedes business co-operation. And finally, through Internet-based searches and specialised information providers, the individual business will be better positioned to identify new potential suppliers and customers. These processes impact the industrial structures through multiple facets: shorter production-cycles and improved responsiveness, information sharing and communications but op and down-stream value chains, and eased identification of business-opportunities and partners, which reduce the societal costs of production. Applied ICTs and DMM-technologies not only reduce the costs of productions but also increase the likelihood that the supply will match demand. The conclusions are extractable through analyses of the following three research-questions.

7.1. Communications in Economics

Research Question 1:

What are the theoretical contributions on information and communication in economics, and what are the roles of communication in industrial processes?

First research-question is truly twofold. On one hand the question relates to the perception of information and communications in economic theories and how these attributes impact the economic analyses. On the other hand it relates to how the identified information-processes impact the industrial processes e.g. outsourcing patterns and value chain structuring. This question has been answered through dual processes of identifying relevant economic theories and their perception of information and communication within industrial activity, and through establishing a communication model that is thought better in analysing the identified information and communication aspects.

Information in economics has been analysed at different theoretical levels related to human capabilities and access, tradability, as communicative language etc. Neither classical nor neoclassical economic theories offer any direct analyses of information. Indeed the neoclassical approach is based on well-informed, all-knowing economic agents, and is hence ill-suited to analyse impacts from ICTs.

Analytical claims of this theory have been founded in this somewhat unrealistic perception of economic agents. Later theoretical schools have instead suggested that economic agents should be understood as restricted in their information-access, and abilities to comprehend and analyse information. Information then becomes important to the economic agents and their actions, where differences in access and capabilities mark the differences between economic agents. With less than complete information and knowledge about economic environment, the agents cannot be trusted to act optimally or fully rational: they become bounded in their rationality.

Bounded rationality leads to some form of institutional processes in decision-making, which have been central to some economic schools. Two forms of neo-institutional arrangements have been identified: functionalist rationality in transaction cost analysis and procedural rationality in evolutionary economics. Economic agents in the first approach can optimise governance structures given the costs of information whereas agents in the latter only can improve through learning and innovating operations.

Information in the transaction cost analysis relates to searches and contracting abilities. Searches of what the true prices are internally in hierarchies and externally at markets are important to identify lowest prices and to optimise governance structures. Entrepreneurs also have to specify contracting conditions i.e. stipulate contractual items and reward systems, which again require extensive information sharing. Opportunism and bounded rationality especially at the markets impact the contracting costs, through more comprehensive contracts. Information is the key to identifying the lowest cost and to structure governance regimes: optimal governance structure is where transaction and production costs combined are the lowest. Information is costly and restricted, and economic agents optimise given their access and abilities to handle information. Application of ICTs and DMM-technologies lead to lower information costs, more information and possibly to altered governance structures.

In the evolutionary approach, information is crucial too. Businesses are governed by routinised activities where organisational structures and patterns dictate production and innovation-processes. The employed resources continuously learn-by-doing within the firm and gradually develop into capabilities: agents get informed about their performances through internal information-loops. Likewise the capable resources develop into core capabilities, which marks the competitive advantage of specialised businesses. The outputs from the business activities are put to markets where selection mechanisms indicate which products and business-routines that are superior to others. Businesses get

informed through the feedback-loops from markets: un-competitive or un-wanted products cannot be sold. Consequently the businesses change their operations or product-ranges governed by their abilities to mutate. The mutated routines result in renewed processes and products, which lead to altered competitiveness at markets. A Darwinist approach stipulates blindfolded mutations whereas a Lamarckian predicts purposeful and direction-oriented developments. Information in this theoretical approach relates to feedback-mechanisms and learning loops, through which the business-resources develop and routines improve. Application of ICTs and DMM-technologies lead to improved internal information-loops and faster and/or better mutations.

Another approach to the evolutionary processes is found in the learning economy, where businesses and agents are still marked by bounded rationality and incomplete knowledge. In order to succeed in competitive environments, the businesses have to establish knowledge about what to produce, how to produce, why they produce and with whom they should produce, which are all subject to the evolutionary learning-procedures described above. Within the learning-approach information get accumulated in deposits of knowledge, where especially knowledgeable businesses are thought to do better than the ignorant ones. Being informed and possessing abilities to learn exactly what to produce before actually producing mark the successful businesses: business-operations and -developments are much more proactive and Lamarckian than the evolutionary Darwinist approach. Through the learning economy the applications of ICTs and DMM-technologies get more detailed - these tools may impact all four areas of business-knowledge differently.

A somewhat different approach to the role of information has been identified in the New Economy: information is here perceived as a separable tradable item, and the core of the analysis deals with economic conditions of information acquisition, production, distribution and trade. Information in this perspective is treated as the output of certain operations and needed as input for other activities and is hence subjectable to trade. Through economy of scale in information handling and improved transmitability the economic paradigm around information and services alter: service provisions can become separated, centralised and globalised through which economic gains of scale, specialisation and from international division of labour get enabled. Differences in information relate to different quantities or personally fitted information services: with improved information-accesses, economic agents become exposed to information overload, and viability of information services relates to provisions of exactly what is needed. Applied ICTs and DMM-technologies are essential to the analyses of the New Economy and information-infrastructures are pivotal. Focus seems concentrated on the quantitative aspects of information.

In addition to the firm-specific characteristics and the economic attributes of information-infrastructure there are other factors that have to be included in analysing the industrial developments. These dimensions relate to the regional and national characteristics that impact the production-conditions of firms in different areas. These characteristics are primarily related to economic externalities related to some geographical condition e.g. local labour markets, competition, cooperation and trust. However, information-accesses and -processes may also impact these localised characteristics. Language may be analysed as a geographically, culturally or technologically unifying medium for transmitting information in local areas and as such will there be competitive advantages related to improved information sharing within such an area. Another approach relates to the abilities to share surveillance-information within certain structures: improved monitoring-abilities and information sharing enhance the information abut others and their trustworthiness. Economic advantages from the surveillance information relate to improved trustworthiness of businesses within these information networks. Applied ICTs and DMM-technologies again impact the economic conditions, here as information levels increase, which reduces the operational costs locally.

Information is an important aspect in all these economic approaches. However, the analytical inabilities of these approaches individually in describing the composition of the textile and clothing industry and the applied ICTs and DMM-technologies have called for an alternative approach to analysing the economics of information and communications. A model has been presented and applied in analysing these information technologies, industrial composition and value chain structures. An important aspect of the applied model is its assumption of bounded rationality and the proactive behaviours of the economic agents. The model epitomises the importance of communicative activities related to information sharing and dialoguing processes through which shared knowledge may be obtained. Information sharing and communications are essential for several reasons: pre-contractual stages of supplier-identification, skills-evaluation, and establishment of worldviews and trust-worthiness, contractual stages of product-specification, interactive developments, and shared fashion/market analyses, and finally in the post-contractual stages of information-feedback and learning.

Personalised communications are required, as substantial parts of knowledge are tacit and not easily communicated: media-rich communications are required for information-exchanges and questioning on the subjective, objective and social spheres. These exchanges of personalised knowledge are especially relevant in establishing worldviews and trustworthiness of other parties, and in forming

shared knowledge about fashion- and market-trends. Increasing volatility in demands, market-segregation, and individualisations puts extra emphasis on these information and communication abilities: productions increasingly hinge on trusted suppliers and a superior market-understanding increasingly hinge on a shared knowledge formation.

In contrast to the other economic analyses the presented model applies a distinction between information and communication. Communication is the act of perceiving the transmitted information, and relates to dialoguing processes and media-rich information-streams. Information is then related to transmission of data through various medias, which is not directly subject to dialoguing processes. Through these distinctions the analyses of developing DMM-technologies contain more qualified aspects related to the dialoguing abilities, of media-richness, and of multimedia in product developments and industrial organisation.

7.2. Information Needs and Provisions

Research Question 2:

What are the information and communication requirements for businesses in the textile and clothing industry, and how do applied ICTs and DMM-technologies satisfy these needs?

Through a range of interviews, survey, and secondary materials, is has become possible to identify the various information-needs experienced by different sectors at different stages of economic activities. And through the outline of the developing ICTs and DMM-technologies, it has become possible to establish how the identified information needs get satisfied. These information-requirements and accesses have also founded the conditions for the proposed analytical model.

Table 7.1: Production modes and conditions

	Unperceived	**Perceived**	**Programmed**
Quality levels	High	Medium-high	Medium-low
Time-span	Short	Medium	Long
Outsourcing steps	Many functions	Single function	All functions
Outsourcing area	District	Extra-district, Europe	International, Global
Relations	Personalised	Integrative	Integrative with market

First and foremost it has been possible to identify differences in the industrial needs for information depending on the competitive strategies of individual businesses and value chains. Interviews and the survey support a three-fold distinction of industrial structures: there are three different modes of production related to the composition of economic risks and time-span of productions. In one extreme, the programmed modes which mark the traditional supply-push production structures, the information and communication-processes relate to displaying products, receiving orders and identifying cheap suppliers notably in Asia. The other extreme of unperceived mode, which relate to unperceived market changes and demand-pull structures, relates primarily to identification of markets-changes and needs for personalised provisions. Here the production processes are primarily organised around personalised relationships. Information processes are hence related to accessing market-information, sharing analyses, enabling integrated production-processes, and shared product-developments for speedy deliveries. Between these there is the perceived production mode based on pre-established designs and on somewhat long-lived personalised ties with nearby suppliers e.g. on sewing services. Information relates not so much to product-development but more to quantitative information on present market-sales and production-performances, and to the communicative feedbacks for learning and upgrading foreign suppliers.

Table 7.2: Knowledge-forms in industrial sectors

	Know-why	**Know-what**	**Know-how**	**Know-who**
Design	Internal motivation, Styles, Artistic values	Trend & fashion analyses, CAD/CAM, Communications	Computers	Skills, Qualities
Textile	Turnovers, Strategies	Trend & market analyses, EDI, CAD/CAM, Communications	Production technologies, Computers	Skills, Qualities, Capacities
Clothing	Turnovers, Styles, Strategies	Trend & market analyses, EDI, CAD/CAM, Communications	Production technologies, Computers	Skills, Qualities, Capacities
Retail	Styles, Strategies	Trend & market analyses, EDI, Communications	Stores, Product presentations, Computers	Skills, Qualities

Different segments of the industry hold different levels of knowledge and possess different core capabilities. Core capabilities and enhanced knowledge levels can be utilised for generating firm-specific competitive advantages, and through divisions of tasks and sharing of information it becomes possible to upgrade performances of entire value chains. The more a given value chain competes in the

high-quality product markets, the more provisions have to respond to the fluctuations in demands and the more it is required with small-batch production processes. Consequently, these chain structures get dependent on accessing and processing information, generating accurate knowledge about market changes, and to share the information with the subcontractors in order to provide speedy, flexible provisions.

All the analysed industrial sectors are relying on establishing the four forms of knowledge: why, what, who, and how. Know-why relates to establishing motivations, which can be associated with financial requirements and internalistic, artistic values. Know-what is the identification of what is needed at the markets, competitor performances, product developments and determination of which quantities that are needed where and when. Know-how relates to production skills and organisations, through which the production get organised and businesses learn. Final field of knowledge relates to knowing who to cooperate with: identifications of skills, costs, trustworthiness etc.

Knowledge about why and who is especially important in the pre-contractual stages where the production owner has to establish who holds the required skills and offers satisfactory trustworthiness, which is tightly connected to the motivations i.e. know-why of the firm, established through shared worldviews. Knowledge of what to produce is likewise crucial to economic performances: developments of designs are primarily based on communicative activities between designers, product owners, but increasingly with other stake-owners. Personalised communications and multimedia structures are again essential in displaying skills and solutions, and for the dialoguing that enables a designer to provide design solutions that satisfy others' wishes. When the exact designs, measures and colours have been established the knowledge is codified and further information can be enabled through barcoding and EDI-messaging. Depending on the risk-evaluation by the different industrial segments, they may choose to provide more or other items than directly detectable at markets, which require through market and fashion analyses. Personalised communications are again essential in enabling shared knowledge about future developments: notably retailers and specialised analysers have superior knowledge about future markets and trends.

Final aspect of the information-needs and acquisitions relates to the post-contractual stages where information is exchanged on production status, quantities, standards etc. Part of this information exchange is codified and transmittable as EDI-messages, but other parts require personalised and media-rich communication structures. Personalised communications are required to discuss qualities and possible improvements, and media-richness in presenting products and to monitor operations. The

better the communication structures the better the businesses are positioned to learn and upgrade deliveries.

Table 7.3: Contractual stages and knowledge formation

	Means	**Achievements**	**Knowledge formation**
Pre-contractual	Personal relations, searches, displayed skills, past experiences	Worldviews & trust	Know-why & Know-who
Contractual	Present ideas, sketch solutions, market & fashion analyses	Product specifications, conditions & reward systems	Know-what
Post-contractual	Monitoring, after-sales services & data	Productions, learning, skills & evaluations	Know-how

ICTs and DMM-technologies are essential tools in support for these information-processes and value chain operations. Some of the most widely applied technologies are e-mailing, EDI-messaging, homepages and CAD/CAM-technologies, but other communication-tools have emerged and are slowly getting more applied e.g. video-telephony, videoconferencing, shared workspaces, and electronic marketplaces. E-mailing has become a useful tool for sharing information and for asynchronous communications, and has due to its low costs and high diffusion rates become applicable in communications with most businesses both in Denmark and abroad. EDI-messaging is on the other hand based on much more structured information, which makes it suitable for transformation of codified data, but also less appropriate for information processes prior to the codifications of products. In addition, the EDI-based information sharing is based on somewhat proprietary standards and technologies, which enhances its costs and restricts its applicability for small businesses. Nevertheless, EDI-messaging is a very important application that assists speedy, accurate transmissions of data, and has become widely applied in communications between retailers, domestic suppliers and major sub-contractors.

The Internet and homepages are increasingly applied information-channels that the industrial businesses utilise to inform about the business, the products and services, and gives information about contacts and sales. The industrial businesses increasingly view homepages and the Internet as important communication tools, and continuously apply these structures for more purposes. Some of the advantages provided are the media-rich information-streams where businesses can display their products and skills in 2-D and 3-D modelling, and where customers can acquire additional information

about the company, the products and possibly even manipulate products for customised provisions. As with the e-mail, Internet-access is relatively inexpensive and homepages are accessible all over the world, which make them suitable for information sharing with all business partners.

Multimedia files have been shared within the industrial structures for decades, and as such is electronic data transfer in support for commercial activities not a new concept. Computer software increasingly assists the design processes: 3-D environments, Internet-based interactivity and file sharing with other standards and systems. An important facility of the CAD-technology is its ability to generate automated files for the CAM-processes: cutting patterns, printing and colouring instructions etc. Another developing facility is the shared Internet-based workspaces, where two or more parties can manipulate the same virtual product. CAD-technologies also enable that the designed products get digitised, visualised and presented in photo-realistic virtual environments, which assist speedy manipulations and selection processes. Further, it becomes possible to present skills i.e. developed designs and products, without prior physical prototyping.

Whereas web-cameras and videoconferencing are only diffusing slowly, electronic marketplaces are emerging quite rapidly. Through these structures it becomes much easier for individual businesses to reach larger markets, and to acquire information. Search-mechanisms enable identifications of business-opportunities, and of new potential business-partners. These marketplaces frequently offer additional information services related to the skills and trustworthiness of businesses, and technology, market and fashion analyses that assist all the required forms for knowledge. When business opportunities and potential partners have been identified, more intensive communications and dialoguing processes get required to establish worldviews, skills and conditions. These communications are increasingly supported by web-based DMM-technologies.

Different software packages increasingly get improved and applied within the industry. With the increasing levels of applications, there are also mounting expectations about their performances related to improving transmission standards and higher-capacity networks. Transmission technologies based on circuit-switched structures enable that data get transmitted: dedicated lines with a direct speedy access ensure low rates of delays and losses. Due to limited bandwidths these structures are mostly suitable for voice telephony and some loss-sensitive data-transmissions, but less suitable for transmissions of the large data-files required by DMM-technologies e.g. video and graphics. Increasingly packet-switched transmission networks are offered, which enable transmission of larger data-packages through larger and more flexible bandwidths. These transmissions are however also

subject to less direct transmissions implying both potential delays and losses, which make them problematic for the online dialoguing videoconferencing tools and for shared workspaces. Improving telecommunication-technologies as ADSL and alternative communication networks as TV-cables are based on asymmetric communications as down-stream information has higher bandwidth than upstream. But continuous improvements in transmission-technologies, bandwidths, compression processes, compatibility of software etc. suggest that loss-less and non-delayed multimedia interactions will soon be reached.

7.3. Impacts from Applied DMM-Technologies

Research Question 3:

How do ICTs and DMM-technologies impact business relations and industrial structuring of value chains?

Answering of research-questions one and two has provided insight into the industrial information and communication-needs and processes both in real terms within industry and at an analytical level i.e. in the identified communication model. Through these answers it has also become possible to detect future developmental-traits given improving ICTs and DMM-technologies. Future developments of the textile and clothing industry in Denmark depend on a number of factors related to market-conditions in Denmark and abroad, and to the actual technological innovations.

Market developments

Danish textile and clothing industry has gradually developed its quality-levels and altered its production-structures. Especially manufacturing of clothing has reached a medium-to-high level of quality based on fine fabrics, accomplished belabouring, and trendy designs that satisfied the Western European consumers. Demands at this market have become increasingly differentiated and volatile within the past decades, and will probably continue that trend in the near future. Concurrently with competitive pressures and market-volatility, increasing level of competition emerge due to increasing number of supplies. Competitiveness of Asia and other low-cost regions continuously improve, which put increasing pressures on existing Danish suppliers.

Competitive strategies by Danish firms and value chains have concentrated on providing higher-quality items based on differentiated products. Differentiations have been pursued through various

strategies: conventional strategy has been to deliver fashionable items i.e. become established as a trend-setting brand, another strategy has been orientated towards provisions of smaller lots or even personalised items made on orders. Yet another strategy relates to developing new product properties: functionalist or intelligent clothing e.g. ergonomic shoes, clothing with GPS, and music-players. In similar veins considerations also relate to provisions of ethic and environmental clothing: ethic clothing e.g. contain guarantees against child-labour, and environmental that production, consumption and disposal processes are corresponding with a sustainable environment. Whereas child labour or underpayments have caught much political attention, the environmental has caught relatively less attention in the medias, but more political attentions resulting in standardisations, certifications and control systems.

Value chains in the Danish industry have been transformed during the past decades, which have resulted in diminishing domestic employments, increasing productivity-levels and increasing exports. The remarkable export performances are related to extensive international outsourcing and increasing import-levels. Imports are higher than exports, but exports no only grow faster than in other Western European countries, exports also grow faster than imports. Increasingly the Danish contributions to the industrial value-added have become confined to information-processing and some highly technological services: designing, administration, and logistics are mostly performed in Denmark, along side with high-tech cutting and printing processes. Increasingly the manufacturing processes get located abroad.

Competitiveness of the Danish textile producers and clothing manufacturers relate to very good analyses of the developing demands at the known regional markets, and flexible provisions of the required items at the right time and price. Notably Germany, Sweden and Norway have become major buyers of Danish clothing. Germany is also an important export-area for Danish high-quality textiles, just as Denmark imports many textiles from Germany. Trade-evidences also indicate that substantial degrees of internationalisation relate to exports of textiles to and imports of clothing from low-cost countries: international outsourcing of sewing. Yet another trend which is less visible in the trade statistics is the total outsourcing process made on Danish designs: patterns are communicated to foreign subcontractors, who manufactures everything locally and exports the final products to Denmark. Notable South Europe and East Asia are such foreign areas of total outsourcing reflected in substantial Danish imports from these regions.

Danish textile and clothing industry relies on combinations of unperceived, perceived and programmed production-modes, and on production-processes located domestically, in Eastern Europe and in Asia. Presently the programmed modes based on long-range planning and global outsourcing is dominating, but as markets increasingly develop towards demand-pull structures perceived and unperceived modes will replace the programmed modes. These modes are characterised by much shorter time-spans to respond in, and has so far been subjected to domestic or European outsourcing structures. District-wise provisions are expensive, and Eastern European provisions based on subcontractors that still need to improve skills and learn. Ideal subcontractors are both cheap and skilled, which is somewhat the case with Asian and Southern European industry. But Asian providers are very distant and Southern European suppliers are becoming more expensive.

Developing trends would be that communication-tools improve both interactivity and flexibility, enabling distribution of information and speedier production-processes: global value chains become viable for perceived production modes as well. Another developmental trend is the Eastern European industries develop their skills faster than their cost-levels increase, and hence they will be viable providers for unperceived and programmed production modes. As the East European suppliers develop skills and costs, new areas will be needed and identified that can provide low-cost supplies. A final option relates to continuous technological improvements especially in sewing, which enable that the manual steps become replaced by machinery: in which case an important imperative for international division of labour gets undermined.

Technological developments

Future developments of the Danish industry depend not only on altered market-conditions but also on the abilities to apply emerging technologies in support for value chain operations and market-analyses. There are some important trends in the development in the industrial production-technology along-side the developing ICTs and DMM-technologies. Developmental traits within the production technology relate to increasing levels of digitisation and automation of processes, which enable that production-processes get increasingly integrated and subject to substitutions of labour with capital. Digitisation of processes related to CAD/CAM-technologies impact that processes get more detailed, operated faster, based on small-batch, automated operations. Through digitisation it increasingly becomes possible to separate information-processes from physical production-operations reflected in separation of design and manufacturing, and outsourcing of computer capacity in marker making etc. Digitisation is also essential to the automation steps where CIM enables that design data get fed into CAM-processes

without manual processing: fully automated processes may hence emerge, which are particularly important for lean production processes and mass-customisations.

Digitisation and automation of processes have been evident within many production-steps: scanning enables digitisation of measurements, designing can become totally digitised, textile production e.g. colouring is increasingly digitised, and manufacturing processes as cutting get digitised as well. However, some important areas are still subject to manual processes notably the sewing and after-sewing processes e.g. ironing. Technological difficulties are still substantial in generating lean sewing technologies that enable continuously monitoring of processes and lean automotive adjustments. Automated assembling-processes are however feasible for some standardised operations, but most clothing depends on human assembling.

ICTs and DMM-technologies have important roles to play in all the production and commercial processes. Some of the most important areas for application of these technologies relate to enhanced market-access, improved fashion- and market-analyses, consumer integration, distributed personalised communication of worldviews, skills and trusts, integration of production processes, virtualised products and interactive virtual environments for product developments, logistics, specialised information services and improved information searches.

Networking abilities improve and more functions get integrated are important for the developments of all these processes. Electronic networks have quite diffuse structures and capabilities, which disable a worldwide uniform communication network, however larger files and multimedia-data get transmitted through continuous improvements in transmission-technologies and in bandwidths. Concurrently hard and software-systems develop and it increasingly gets possible to operate in virtual, interactive environment: DMM-technologies develop in support for shared workspaces, virtual meetings etc. Crucial to the development of a worldwide industry-wide information highway is that data get structured in ways that are easily transmittable and accessible so that operations can get standardised and functions become integrated. Major improvements are the hypertext protocol layer fundamental to the operations of the Internet, and the markup languages important to the structure of documents. Notably, XML-standards are important to the future data-structures and information sharing for the industry: through industry-wide standards, codifications and search procedures are vastly assisted. And universal standards for video and audio compressions have been important for the distributed access to multimedia-files e.g. in the increasing compatibility of CAD/CAM-systems.

At present, ICTs are applied extensively by industry notably in support for logistic managements e.g. e-mail and EDI-messaging. Other commercial processes are increasingly supported by homepages, and virtual presentations. With the continuous technological improvements and mounting competitive pressures DMM-technologies in support for online interactivity will increasingly get applied. Some of the most important aspects from the DMM-technologies are in the pre-contractual personalised communications of worldviews and skills, the contractual communications where personalised communications are required in comprehensive analyses of markets and trends, and where interactive shared workspaces are needed for product developments and alterations, and finally in the post-contractual stages where distributed monitoring and feedback mechanisms are required. The economic potentials from these communications and abilities to interact have been discussed in detail, which have pointed to better identification mechanisms, evaluations of trustworthiness, improved knowledge of what to produce, speedier production alterations and improved learning mechanisms.

Concurrently or consequently the value chain operations and conditions will change. Production-processes will become speedier and more flexible and sequences of adding value to products alter, as the short-term production modes will increase in importance. And new levels of interactions will be introduced that enable customer-integration and improved learning mechanisms, where individual businesses, local areas and nations may improve skills more speedily. New businesses will be identified at greater ease through brokerage services, skills and trustworthiness will be established through distributed communications, which assist globalisation of value chain structures. And new services and business models will emerge related to provision of information services, which all in all points to increasing levels of outsourcing and increasing globalisation of processes, especially information intense services.

Extracts

Distributed Multimedia Technologies and Value Chain Structuring – An Economic Theory of Communications

This doctoral thesis has investigated the socio-economic transformations resulting from improved communications enabled by evident innovations in information and communication technologies (ICTs) in past years. The academic curiosity has resided with the emphasis on full information and near perfect markets in economic theory, which seems unrealisable in real-world settings. Henceforth, the thesis has investigated the actual communication and information-needs in an industry i.e. the Danish textile and clothing industry, and the communicative abilities provided by developing ICTs. Through a parallel investigation of the case and the technology with economic theory it has become possible to construct a communication model that describes the communicative activities in an industry. Furthermore, the proposed communication model has been compared to some established economic theories in order to identify overlaps and differences. In concluding, the model has described the communication-structures within an industry, which is somewhat different from other economic analyses. This model has offered a framework for understanding information- and communication-processes in support for industrial activities. Through this model it has become possible to identify information and communication-needs, industrial motives for applied ICTs and importantly the socio-economic impacts from applying ICT.

The thesis draws the conclusions that industrial applications of ICTs do have evident effects on the industrial structures, and that a pivotal contribution from these communication-tools is the ability to communicate intensively amongst companies, both up and down-stream the value chains. These enhanced communication-structures hold the potential to transform markets from being supply-pushed to become demand-pulled, and hence they increase the likelihood that markets will operate better. Enhanced communications will potentially impact three major areas: identification of suppliers, communication of consumer-preferences and reducing time-requirements in production. All are thought to be beneficial for a smooth clearing of markets.

A fundamental developmental trait of the past decades has been that ICTs have developed rapidly. Gradually the telecommunication-infrastructures have expanded through larger bandwidths, competing

networks and accesses to the information-highway, and a liberalisation of the telecom industry has motivated higher levels of competition, better services and lower price-levels. Concurrent with the infrastructure-developments innovations in computer-technologies have radically altered our abilities to interact in distributed networks. Information technologies improve as computers' processing-abilities increase, storage-capacities multiply and hard- and software programmes increasingly support interactivity and sharing of files. One important trend is the lowering of prices on some computer hard- and software, which together with diffusion of tele-infrastructures have enabled that both private users and businesses possess these communication tools. More and more agents get connected to electronic networks e.g. the Internet.

Another important trend of ICTs is the gradual expansion in data-transmissions, which support increasing on-line interactivity. Enlarged bandwidths facilitate more rapid transmissions of large data-files, which support sharing of media-rich data. Distributed Multimedia (DMM) technologies based on the simultaneous application of multiple media e.g. video, audio, texts, graphs, and images are increasingly supported. Through applying DMM-technologies it become possible to interact electronically in distributed structures e.g. virtual meetings through videoconferencing and virtual workspaces through sharing of data-files in design and manufacturing. An important aspect of the developments in DMM-technologies is that networks increasingly support the sharing of large data-streams and hence they support for more and more media-rich communications irrespective of geographical location. Nevertheless, hard- and software technologies still need to be improved in order to provide seamless virtual interactivity: software programmes must interact better based on shared standards and improved compression-tools if virtual interactivity is to be obtained through the existing tele-infrastructures. Continuous developments in tele-infrastructure and increasing compatibility of hard- and software suggest that it will only be a question of time before large-scale distributed interactivity will be reached.

Danish textile and clothing industry has been analysed in order to investigate the impacts from applied ICTs and DMM-technologies on industrial operations. This particular industry has been chosen for numerous reasons of which the most important are stipulated below. The academic curiosity has centred on the theoretical notion of full information and this case seems to be a good example of an industry where full information is lacking: continuous mismatches between supply and demand result in discounts or out-of-stock situations. Manufacturing of textile and clothing has be come subjected to international value chain structures where some production-steps have been outsourced to other companies both locally and abroad. Continuous competition compels the Danish industry to react and

do whatever possible to remain competitive, which have resulted in international outsourcing of labour-intensive functions, outsourcing of specialised activities to other businesses, increasing information sharing with partners in the value chains to improve demand-forecasting, and shortening of production cycles in order to increase responsiveness to market-changes. The continuous competitive pressures and internationalisation of markets are thought to motivate the businesses to apply DMM-technologies in support for commercial activities.

Analyses of the Danish textile and clothing industry have contributed through outlines of the industrial communication-processes and –needs, and by identifications of applied ICTs and DMM-technologies. The case has revealed that viable value chain operations depend on information sharing and communications between the different businesses, and that this information is distributed differently. At one end, the retailers have a unique access to information about customers and their preferences e.g. through analyses of sales-data and personal communications. Parts of this information get distributed to manufacturers e.g. through codified ordering (EDI-messages), through e-mail and personal meetings between sales-representatives and retailer. Data on stocks, orders and processes are also shared between manufacturers and sub-contractors, however communications with foreign sub-contractors are mostly based on personal meetings, faxes and phones. The limited applications of ICTs and DMM-technologies rest partly with the inappropriateness of codifying pre-assembled items and with lacking ICT-skills and resources abroad. These tools are however applied in communications between Danish companies and their foreign subsidiaries e.g. in the form of e-mails and computer-aided design and manufacturing (CAD/CAM). Digitised communications are also applied in communications between designers and production-owners, notably in the form of CAD-files, which are directly applicable in the manufacturing processes.

A detailed investigation of the Danish textile and clothing industry has revealed that the industry has remained an important contributor to international trade and domestic value-added. Through the past decades the industry has been radically transformed from being primarily labour-intensive to become much more information and service intensive. Substantial parts of the labour-intensive processes have been shifted to Poland and the Baltic countries, and the remaining operations have increasingly become digitised. Consequently, substantial parts of the domestic employment of the industry have terminated. Restructuring of this industry has been coupled with increasing international competition where European and Asian competitors increasingly supply textile and clothing for Danish manufacturers and final markets. Altered competitions have highlighted the information intensive design and management operations, which still reside in Denmark. An important means to remain

competitive has been to construct faster production-cycles e.g. through digitisation, and through intensive market analyses. Faster production-cycles have developed through decades of cooperation and an improved market understanding has been obtained through direct access to sales-data. Combined these features have enabled a vastly improved responsiveness to demand-fluctuations.

Three different value chain structures have been identified related to varying levels of quality, outsourcing and time of production and distribution. A “programmed” production-mode has been identified as the dominant structure. Within this conventional supply-push mode of production, designers and production owners establish designs, present models at fashion shows, receive orders, and initiate production and distribution. These processes often endure 15 to 20 months, and due to the long planning-period international outsourcing of all production steps are feasible. Very short-time production-cycles applied for flash products i.e. “unperceived” production-modes, present another extreme. Within this structure orders are received before or concurrently with design-developments, and production-processes are primarily based on district-wise outsourcing patterns, which enable provisions within a 6-8 week time-span. In-between there is a “perceived” production-mode primarily related to replenishments, based on international outsourcing of sewing and 2-3 months delivery times. Increasing international competition and needs for shorter production-cycles also shift the international outsourcing-structures and applications of ICTs. Trends towards speedier processes and more flash-products highlights the needs of interacting on design-developments, access to speedy sales-data and application of ICTs.

Through the combined analyses of ICTs and the case it has become possible to identify the industrial communication-needs and supports from technology, which have led to construction of a communication model. Identification processes have led to schematisation of knowledge-forms and accesses: all businesses of the industry have to establish knowledge on “why”, “what”, “who” and “how”. Know-why relates to the internal and external requirements that condition the economic processes. Know-what relates to determination of what the markets need at different times. Know-how is knowledge about production processes, and know-who is knowledge about who is skilled, holds capacities and is trustworthy.

These knowledge-forms relate to different steps of transacting and producing: in a pre-contractual stage the businesses must know why they produce and who to cooperate with, which get facilitated through fairs and communicated through personal meetings. In the contractual stage the business must generate knowledge on what to produce, which is the outcome of market- and fashion-analyses and

communications with consumers and suppliers. Increasingly management-tools develop in support for market-analyse just as specialised information services develop e.g. electronic journals, and communications of what to produce also get supported through electronic image-presentations and virtual workspaces. And finally in the post-contractual stages the business must acquire knowledge on how to produce, how production is progressing etc. facilitated through ICTs as EDI-messages, and through DMM-technologies as web-cameras.

Generally the DMM-technologies seem to be supportive in three distinct areas. Through web-cameras it has become possible for businesses to monitor others and through improving interactivity, these tools may eventually support virtual meetings. Through virtualisation of the human interaction it will become feasible to communicate and interact with new businesses in distant places without prior physical meetings. DMM-techniques are also applicable by individual companies to display their skills and products. Browsing through web pages for products and skills it becomes possible to identify new businesses. Industry-wide XML-based codifications and Internet-browsing are though especially helpful in identification of new businesses. And finally, distributed interactivity mediated through shared files enable that designs and products get presented in virtual environments and modified through shared processes. This not only assists the presentation of skills and products but also assist specification of what to produce.

Chapter two of the thesis has stipulated the theoretical and methodological conditions for the thesis, and offered an introduction to the communication model. Chapters three and four have offered outlines of general developments in ICTs and the Danish textile and clothing industry. The communication model has been applied in chapter five, in which it is revealed how ICTs and DMM-technologies get applied. The findings from this chapter have been compared to some established theoretical contributions in chapter six. Four economic theories have received special attention due to their appropriateness in explaining elements of the economic activity of the industry. The roles of information have been analysed in the information economics of the New Economy, the cost of information has been analysed through transaction cost analyses, limited information has been the subject of evolutionary and learning economics, and finally industrial economics have been applied to analyse information externalities. Through comparing these theories to the presented case it has become apparent that they somehow lack abilities to explain the industrial activities, and hence that an alternative communication model is needed.

Some of the conclusions relate to the inappropriateness of the established economic theories. Briefly put, the information theory of the New Economy has stressed the role of information networks, the economics of competing networks etc. Acknowledged, theoretical contributions have also pointed to the general transformation towards information-intensive industrial developments, but these have tended to concentrate their analyses on the telecom industry. Only limited attention has been given to the transformation of conventional manufacturing industries, and how improved communication-tools impact the conventional manufacturing processes. Limited information, which has been the core of the learning economy, has referred to individual information-accesses and abilities to comprehend the environment. Applied ICTs and DMM-technologies not only shifts the boundaries for information-access, they also empower industrial restructuring and completely altered communication processes e.g. communication both up- and down-stream value chains. Thus, the ICTs not only relate to other quantities but also qualities of information. Transaction cost analyses have emphasised the costs of acquiring information, and ICTs are though instrumental in accessing information through electronic networks. However, ICTs and DMM-technologies in particular hold the possibility for media-rich personalised communications, which are though instrumental in establishing shared worldviews and trusted relationships. Again, applied DMM-technologies assist qualitatively better information. And finally, the industrial economics notably industrial district economics have stressed the regional economic externalities. However, to some extent the externalities are related to information sharing that can be communicated through electronic networks, and hence will the application of DMM-technologies nullify some geographical advantages and question the appropriateness of the analytical approach.

Through investigation of the analysed industry and through stressing the emerging potentials from DMM-technologies it has become possible to envisage the future industrial developments. The communication model demonstrated in chapter five, have stressed the qualitative component of data transmissions mediated through DMM-technologies. Through this emphasis it becomes possible to imagine that the future industrial developments will stress applications of ICTs and DMM-technologies. Skills to handle these technologies will only gradually mature and hence, the Danish industrial district will hold a comparative advantage also in the near future. It is likely that markets will develop further towards consumer-segmentation and short-lived sales-periods for products, increasingly flash-productions will dominate and hence there will grow a larger need for virtual presentations of products and virtual workspaces. With the emphasis on short production cycles, it is likely that Eastern European sub-contractors will maintain or even expand their industrial activities given that they increase their application of ICTs.

Dansk Resumé

Distributed Multimedia Technologies and Value Chain Structuring – An Economic Theory of Communications

Denne Ph.d.-afhandling har bidraget med en analyse af de socioøkonomiske transformationer, der opstår som resultat af forbedrede informations- og kommunikationsteknologi (IKT). Den akademiske analyse har været motiveret af den åbenlyse diskrepans imellem den fulde information, som økonomiske agenter antages at besidde i økonomisk teori, de antageligt næsten perfekte markeder og så det der kan konstateres i virkeligheden. I forlængelse af dette har Ph.d.-projektet beskæftiget sig med de egentlige kommunikationsbehov og –processer som de udfolder sig i en given industri i.e. den danske tekstil og beklædningsindustri, og hvordan den forbedrede IKT understøtter den kommercielle kommunikation. Det har været muligt at konstruere en kommunikationsmodel, som kan beskrive den industrielle kommunikation. Modellen, som er fremkommet gennem den parallelle analyse af industri og teknologi, er også blevet sammenholdt med nogle etablerede økonomiske teoriretninger for at fremhæve dens forbedrede analyseevner. Det bliver konkluderet at modellen bedre end de andre teoretiske strukturer kan beskrive den industrielle kommunikation og dermed tilbydes en forbedret analyse af de socioøkonomiske transformationer.

Industriel anvendelse af IKT har en betydelig effekt på de industrielle strukturer, hvilket er en af denne afhandlings hovedkonklusioner. Et væsentligt aspekt af disse kommunikationsredskaber er den forøgede mulighed blandt virksomheder til at kommunikere både op og ned gennem værdikæderne. Via denne kommunikationsproces opstår der et potentiale til at transformere traditionelle udbuds-styrede markeder til efterspørgselsstyrede, hvilket også øger muligheden for forbedrede markeds-mekanismer. Den øgede kommunikation vil især have indflydelse på følgende tre områder: identifikation af forretningsforbindelser, distribueret og integreret information om forbruger-præferencer, samt reduktion af tidsforbruget i produktion. Alle disse effekter er medvirkende til at gøre markederne mere velfungerende.

IKT har undergået en betydelig forvandling igennem det seneste årti. Generelt er teleinfrastrukturen blevet udvidet gennem øget båndbrede både i backbone og for en enkeltes adgang til de fælles netværk, konkurrerende netværk er opstået, og liberalisering af telecom sektoren har forøget konkurrencen, medført bedre serviceniveauer, og været medvirkende til et reduceret prisniveau. Samtidigt har forbedringer indenfor computer hard- og software forandret vores muligheder for at kommunikere gennem elektroniske netværk. Informationsteknologierne er blevet forbedrede eftersom computernes processorer er blevet større og hurtigere, lagringskapaciteten er blevet forøget, og eftersom hard- og software programmerne til stadighed understøtter interaktivitet og fil-delinger. En åbenlys trend har været de reducerede omkostninger ved computer hard- og software og den billigere telekommunikation, som har bevirket at disse kommunikationsredskaber nu findes både i private hjem og i virksomheder. Flere og flere bliver tilknyttet de elektroniske netværk så som internettet.

En ligeså vigtig trend indenfor IKT er den forøgede evne til at transmittere store data-filer. En forøget båndbrede understøtter hurtigere transmissioner af store data-mængder, hvilket understøtter både real-time interaktivitet og medierige data. Distribuerede multimedie (DMM) teknologier, som baserer sig på samtidig anvendelse af flere medier så som video, audio, tekst, grafik, og billeder bliver til stadighed understøttet. Via DMM-teknologierne bliver det muligt at interagere elektronisk distribuerede netværk f.eks. virtuelle møder gennem videokonferencer, og virtuelle rum gennem delte design- og produktionsfiler. Et meget vigtig element af denne udvikling er at det bliver stadig lettere at kommunikere og anvende medierige værktøjer uanset ens geografiske placering. Ikke desto mindre er der stadig behov for videreudvikling af disse teknologier førend det bliver muligt at interagere gnidningsfrit i virtuelle rum: programmer skal baseres på fælles standarder og komprimerings-værktøjerne skal forbedres. De kontinuerlige forbedringer i teleinfrastrukturen og IKT generelt gør det til et spørgsmål om hvornår vi opnår adgang til et tilfredsstillende niveau for distribueret interaktivitet.

Den danske tekstil og beklædningsindustri er blevet analyseret i bestræbelserne på at identificere socioøkonomiske forandringer der resultere fra anvendt IKT og DMM-teknologi. Der er flere gode grunde til at netop denne industri er blevet udvalgt, herunder følger de væsentligste. Eftersom den akademiske nysgerrighed har været styret af forundring over misforholdet imellem den teoretiske antagelse om fuld information og perfekte markeder, og de faktiske forhold, er denne industri øjensynligt et godt eksempel på begrænset information: der er til stadighed et misforhold imellem udbud og efterspørgsel som resulterer i udsalg eller udsolgte varer. Produktionen af tekstil og beklædning er til stadighed blevet internationaliseret hvor de enkelte produktionsstep i værdikæderne er blevet outsourced både nært og fjernt. Den internationale konkurrence er blevet hårdere og det

tvinger de danske virksomheder til konstant at søge nye veje for at forblive konkurrencedygtige. Dette har blandt andet resulteret i international outsourcing af arbejdsintensive opgaver, outsourcing af specialiserede opgaver til andre virksomheder, øget informationsdeling imellem værdikædens virksomheder og kortere produktionscykler. Det fortsat høje niveau for international konkurrence tvinger virksomhederne til at reducere omkostninger, øge fleksibiliteten og anvende DMM-teknologi.

Analysen af den danske tekstil og beklædningsindustri har bidraget med en identifikation af de industrielle kommunikationsbehov og processer, og med en identifikation af den anvendte IKT og DMM-teknologi. Casen understreger behovet for informationsdeling og kommunikation imellem virksomheder indenfor de enkelte værdikæder, samt at forskellige kommunikationsprocesser benyttes imellem forskellige segmenter. Detail-ledet har en unik adgang til salgs- og kundeinformation, som delvist bliver formidlet videre til leverandørerne f.eks. gennem kodificerede meddelelser, gennem e-mail og gennem personlige møder. Produktions-, lager-, ordre- og procesdata bliver også delt imellem producent og underleverandør, men kommunikationen er her oftere baseret på personlige møder, fax og telefonbeskeder. Den begrænsede anvendelse af IKT og DMM-teknologi skyldes dels vanskeligheder ved at kodificere halvfabrikata samt lave IKT-kompetencer hos udenlandske under-leverandører. Disse kommunikationsværktøjer bliver dog anvendt i kommunikationen imellem danske virksomheder og deres udenlandske datterselskaber f.eks. e-mails og Computer-aided design og manufaktur (CAD/CAM). Digitaliseret kommunikation er også benyttet i kommunikationen imellem designer og producent, især bliver CAD-filer delt idet de kan indgå direkte i den digitaliserede produktion.

Den detaljerede gennemgang af den danske tekstil og beklædningsindustri har afsløret at den stadig bidrager væsentligt til den internationale samhandel og den nationale værditilvækst. I de forgangne årtier har industrien været udsat for en radikal transformation fra en arbejdskraftintensiv industri til en informations og service intensiv sektor i Danmark. Væsentlige dele af de arbejdskraftintensive processer er blevet forflyttet til Polen og Baltikum, og de resterende produktionsprocesser er blevet mekaniserede og digitaliserede. Dette har medført en kraftigt reduceret indenlandsk beskæftigelse. Den industrielle omstrukturering her gået hånd i hånd med øgede østeuropæiske og asiatiske leverancer. Den forandrede konkurrence har understreget de informationsintensive processer indenfor design, logistik og management som fortsat er placeret i Danmark. For at de danske virksomheder kan fastholde deres konkurrencedygtighed har det været nødvendigt at forbedre deres markedskendskab og reducere produktionscyklerne. Hurtigere produktionsprocesser og forbedret markedsinformation er blevet opnået gennem årelangt samarbejde med de øvrige virksomheder i værdikæderne samt gennem

intensiv kommunikation. Tilsammen har de bevirket at virksomhedernes fleksibilitet og tilpasnings-evne er blevet øget væsentligt.

Tre former for værdikædestrukturer dominerer denne industri. En ”programmeret” produktionsform dominerer de andre former. Denne konventionelle udbudsstyrede produktionsform er centreret omkring producenten, der sammen med designeren sammensætter modeller og kollektioner, præsenterer modellerne på modeshows, modtager ordre og initierer produktion og distribution i nævnte rækkefølge. Tilsammen tager disse processer ofte imellem 15 og 20 måneder, og på grund af den lange planlægningsperiode er det muligt at benytte international leverandører i samtlige led. I den anden grøft er de allerkorteste produktionsformer: ”uerkendte” former, som primært benyttes ved produktion af flash-kollektioner. Denne produktionsform er mere efterspørgselsstyret idet at ordrerne modtages før eller samtidig med at designet udvikles, og først derefter påbegyndes produktionen. Det væsentlige tidspres indenfor disse strukturer gør at det ofte er virksomheder indenfor distriktet, der anvendes i produktionen, hvorved det bliver muligt at levere produkter indenfor 6 til 8 uger. Herimellem er der den ”erkendte” produktionsform som relaterer sig til genbestilling af varer, baseret på international outsourcing af syning og med 2 til 3 måneders leverancer. Den øgede internationale konkurrence og tendensen til hurtigere leverancer påvirker den internationale arbejdsdeling samt behovet for IKT. De hurtigere processer og en øgede vægtning af flash-produktion understreger behovet for DMM-teknologier, der understøtter interaktiv designudvikling og adgang til markeds-information.

Igennem analyserne af IKT og casen er det blevet muligt at identificere de industrielle kommunikationsbehov og hvordan de understøttes af teknologien. Analyserne har også været fundamentale i konstruktionen af den anvendte kommunikationsmodel. Identifikationsprocesserne har bidraget til en rubricering af vidensformer: alle virksomheder har behov for at etablere viden om ”hvorfor”, ”hvad”, ”hvem”, og ”hvordan”. Hvorfor relaterer sig til interne og eksterne krav og forventninger, som bestemmer virksomhedens rammer for handlen. Hvad bestemmer hvilke produkter og services markedet behøver på forskellige tidspunkter. Hvordan relaterer sig til viden om at producere de nødvendige outputs, og hvem er afgørende viden om hvem der har ressourcer og er troværdige.

Disse vidensformer har afgørende indflydelse på virksomhedernes forskellige transaktions- og produktionsfaser. Det er essentielt i prækontraktfasen at virksomhederne ved hvorfor de producerer og hvem de skal samarbejde med, hvilket ofte er blevet understøttet gennem personlige møder, mode-

shows og messer hvor virksomheder har præsenteret deres troværdighed og evner. DMM-teknologier kan understøtte disse funktioner via virtuelle møder m.v. I kontraktfasen er det vigtigt at virksomheden præciserer hvad der skal leveres hvilket afhænger at en udbygget viden om markedets behov og udvikling, blandt andet muliggjort via kommunikation og datadeling med detail-ledet. Igennem den seneste periode er der fremkommet mange IT-baserede hjælpemidler, som understøtter denne viden f.eks. elektroniske journaler og online analyser, ligesom DMM-teknologier understøtter imagepræsentationer, virtuelle rum m.v. Og slutteligt er det væsentligt at virksomhederne i den postkontraktuelle fase etablerer viden om hvordan de skal producere, hvordan produktions fremskrider etc. Dette kan kommunikeres via IKT så som EDI-beskeder og gennem DMM-teknologier som web-kameraer.

Generelt syntes DMM-teknologierne at have væsentlig indflydelse på tre væsentlige områder. Gennem web-kameraer er det muligt at overvåge produktionen og interagere med andre virksomheder som ligger langt væk, ligesom de muliggør virtuelle møder. Virtuelle møder vil med tiden kunne erstatte fysisk fremmøde og muliggøre nye samarbejdsformer indenfor industrien. DMM-teknologierne vil ydermere kunne anvendes af virksomheder til at vise deres produkter og evner, Ved at browse gennem web-sider er det muligt identificere nye virksomheder, der kan levere de fornødne produkter eller services. Industribaserede XML-standarder og internetbaserede søgemaskiner vil være særligt interessante når det gælder identifikation af nye forretningsforbindelser. Og endeligt vil den distribuerede interaktivitet medieret gennem delte CAD/CAM-filer og virtuelle rum muliggøre at designs og produkter bliver præsenteret og bearbejdet i virtuelle rum. Virtuelle præsentationer muliggør en bedre udstilling af produkter og evner, og virtuel interaktivitet understøtter virtuel produktspecificering og viden om hvad der skal produceres. Samlet bidrage disse DMM-teknologier med væsentlige elementer til at virtualisere forretningsforbindelser og interaktion.

Denne afhandlings kapitel to fremstiller de teoretiske og metodiske præmisser for afhandlings rammer, ligesom det introducerer den konstruerede kommunikationsmodel. Kapitlerne tre og fire gennemgår henholdsvis den generelle IKT udvikling og den danske tekstil og beklædningsindustri. Kommunikationsmodel er anvendt i kapitel fem hvor industriens kommunikationsstrukturer og anvendelse af IKT bliver gennemgået. Resultaterne fra kapitel fem er blevet sammenlignet med udvalgte økonomiske teorier i kapitel seks. Fire økonomiske retninger er blevet udvalgt med hensyn til deres egnethed til at analysere den nævnte industri og teknologi. Informationers rolle er blevet analyseret via informationsøkonomien fra ”den ny økonomi”, informationers omkostninger er analyseret via transaktionsomkostningsanalysen, begrænset information er behandlet via evolutionær

og lærende økonomi, og endeligt er industri økonomi anvendt til at analysere informations eksternaliteter. Ved at sammenholde disse teorier med den gennemgåede case har det været muligt at fremhæve de enkelte teoriers manglende evne til at redegøre for industriens kommunikations- og informationsstrukturer. Derved har det også kunnet konkluderes at en alternativ kommunikations-model har været nødvendig.

Nogle af de væsentligste konklusioner relaterer sig til de teoretiske analysers mangler når det gælder DMM-teknologiers anvendelse indenfor denne form for industri. Kort fortalt så har informationsteorien i "den ny økonomi" fremhævet informationsnetværkenes betydning, økonomien ved konkurrence netværk etc. Denne teori har også pointeret den generelle tendens hen imod informations og serviceintensive industrier, men har haft en udpræget fokusering på service og tele-kommunikationsindustrien. Producerende industrier som tekstil og beklædningsindustrien har kun fået en ubetydelig opmærksomhed. En teoretisk mangel bliver derfor i analysen af hvordan en industri, der ikke kan transmittere kerneleverancer elektronisk der ej heller lever af telekommunikationen påvirkes. Begrænset information, som er den centrale antagelse indenfor evolutionær og lærende økonomi, har ofte refereret til individuelle begrænsninger. Analyser af IKT og DMM-teknologier indenfor denne skole har således fokuseret på de ændrede informationsadgange ud fra kvantitative antagelse. Men en væsentlig pointe ved den anvendte kommunikationsmodel er de kvalitative kommunikationsaspekter: et kvalitativt aspekt af kommunikationen relaterer sig til vidensdeling og duale informationsstrømme op og ned gennem værdikæder. Transaktionsomkostningsanalysen har understreget omkostningerne ved at tilegne sig informationer, og IKT er blevet analyseret i forbindelse med lettere adgang til kvantitative data. Men som ved forestående analyse viser denne også en forsimplet forståelse af information og kommunikation: DMM-teknologier muliggør en personlig kommunikation der understøtter konstruktion af fælles verdensbilleder og troværdighedsskabelse. Slutteligt, har industri økonomien herunder teorier om industrielle distrikter fremhævet regionale eksternaliteter, som specielt gunstige for særlige industrier. I den udstrækning at eksternaliteterne har rødder i speciel information vil udbredelsen af elektroniske netværk og anvendelsen af DMM-teknologier underminere de geografiske fordele og denne teoris egnethed.

Gennem analyser af den valgte industri og gennem identifikation af kommunikationspotentialet i DMM-teknologierne er det blevet muligt at fremsætte nogle forventninger til den fremtidige industrielle udvikling. Kommunikationsmodellen i kapitel fem har understreget det kvalitative aspekter af DMM-teknologier og deres økonomiske potentialer. Det er også blevet fremhævet at disse teknologier sandsynligvis vil blive bedre og mere udbredt både i industrien og geografisk set.

Dygtighed og ressourcer til at anvende disse teknologier udvikler sig kun gradvist og derfor har det industrielle distrikt i Danmark en komparativ fordel i forhold til mange andre lande, som forventeligt vil kunne fastholdes. Det er også sandsynligt at tendensen hen imod markedssegmentering og korte salgscykler vil blive mere udbredt, flash-produktioner vil dominere og behovet for virtuelle produktpræsentationer og fælles virtuelle produktioner vil vokse. Med den øgede vægtning af kort produktionscykler er det også sandsynligt at de østeuropæiske underleverandører vil fastholde eller tilmed øge deres andel af den industrielle produktion, især hvis de lærer at håndtere IKT og DMM-teknologier.

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Appendix A – Research Processes

Collecting and organising data as well as processes of analysing data and theoretical contributions have been conducted in a highly flexible way that has not given any predefined order of events. Indeed the sequence of the analytical steps has emerged as a natural process where one step has lead to the next. In very broad terms the order of steps has been as follows:

- Case description through secondary sources.
- Analysis of economic theory on transaction costs
- Case analysis based on interviews
- Analysis of economic theories on industrial districts and evolution
- Case analysis based on online data collection
- Analysis of non-economic theories
- Formulation and construction of a model and research method.
- Final analyses of collected data and research model.

The range of information collected in support for analysis and theorising in this work has sought to cover most aspects of the industry and theoretical contributions. The sources covers both primary and secondary sources at both aggregated and individual levels like:

Interviews: in Denmark and Italy, with personnel close to decision-making and strategy formulation in IT, production and/or finance. Interviews have been conducted in both Denmark and Italy within approx. 10 firms and 10 organisations close to the industry and districts. These sources have revealed the present issues and barriers of the industry and their approach to ICTs. Interviewed businesses in the industrial district have been selected through cooperation with the regional industrial council (Erhvervsrådet) who has assisted in finding some firms that were representative either as frontrunners and laggards. Subsequent interviews have been performed with businesses outside the industrial district, which I have identified through the aid of the Employers' Federation's statistical data on their members. And a string of interviews with organisations have been performed in order to grasp the general conditions of the industrial environment and the needs covered by the organisations' services.

Loosely structured interviews have been applied where I have asked the interviewee to tell about considerations, strategies and results. My questioning of the respondent has been inspired by a list of issues that I wanted the interviewee to cover. This interview-form has been used, as it probably would

reveal more about the businesses experiences and analyses, and less about my own expectations than through more structured interview-processes.

Questionnaire: has been developed and distributed to the 270 firms that are members of the Danish employers' Federation "Dansk Textil og Beklædning". 12 were returned, which have indicated some general industrial trends, but not been applicable to support any stringent statements. Even though the questionnaire was distributed with the aid of both the regional council and the employers' Federation, there were very few respondents. The low return-rate was nevertheless somewhat expected by the Federation as the firms frequently receive questionnaires, and secondly as the competitive pressures are immense, they are extremely reluctant to reveal any strategic information.

Literature: various case studies of the Danish and Italian cases have been analysed in order to grasp the past and present features of this industry, and in order to identify similarities and differences between the cases.

Firm descriptions: on all firms of the Danish Textile Federation have been collected. Data on each firm has been extracted from the federation's homepage (www.textile.dk), from Kraks online business information homepage (www.krak.dk), from Børsen's online business information homepage (www.boersen.dk), and from Kompass' online business information homepage (www.kompass.dk). These data give together with analysis of the individual firms' own homepage an overview of the application of ICTs, core businesses, performances and internationalisation.

Industry news: has been collected through online services like the American world industrial news through Just Style (ww.just-style.com) and the Bobbin Magazine (www.bobbin.com). These sites have contributed with the latest updates on the industry composition in various countries (e.g. Denmark and Italy), and with information on the latest development in trends and styles as well as in information and production technologies. More inclusive technical and industrial news for Denmark have been acquired through online services like Pressmedia (www.peasy.dk), BizReport (www.bizreport.dk), and eStart (www.estart.dk).

Industry conference: in Como, Italy 2000 has provided an insight into the present status applied ICTs and on the barriers posed on some of the leading European firms in the industry.

Technology news for textile and clothing: have been primarily been collected through online information searches. Webpages from the two major providers of production technology for the textile and clothing industry i.e. Gerber (www.gerbertechnology.com) and Lectra (www.lectra.com) have disclosed the latest developments of ICTs within this industry.

E-commerce news: has been collected through numerous online news updates like IDC (www.idc.dk), eMarketer (www.emarketer.com), and Computerworld (www.computerworld.dk), and through downloaded reports from OECD, consulting agencies etc.

Statistical information: on aggregated levels have been collected from Statistics Denmark (www.dst.dk) both in forms of their published data, and as special data-collections. This data has been instrumental in identifying the dimensions of this industry in Denmark, and in order to investigate compositions of value formation and value chain constructions. Statistical data on a more international character has been acquired from e.g. Eurostat (www.europa.eu.int) and OECD (www.oecd.org).

Information on various theoretical approaches and how they apply to this particular case has been investigated through literature studies, case studies and own writings:

Literature studies: have included work central to theoretical frameworks of transaction cost economics, evolutionary economics, and theories on industrial districts. Most articles have been from a single of the three theoretical frameworks, but a few have encompassed more than one. Articles applying the theoretical structures on the case have also been analysed. Finally, part of the theoretical studies has been centred on e-commerce.

Writings: on the theory and case has been done in order to combine the different theoretical frameworks with the Danish case. Writings include articles published in journals and at conferences, as well as synopsis for discussions at doctoral seminars.

Academic environments: and discussions in some different environments have been influential too. The relevant academic environments include CTI and, Technology assessment and economics group at Technical University of Denmark, Telecome Italia's research unit at San Salvador, Venice and Venice Business School.

Seminars: have been followed on applied ICTs in various industries and on theoretical issues. The theoretically focused seminars include summer schools in evolutionary economics (1998) and the ECIS doctoral consortium, Vienna 2000. Seminars on ICTs include the DMIT 1999 and 2000 as well as CTI's annual conferences.

Presentations: have been formed continuously through the period, with different focuses and for different forums. Teaching in courses on economics and DMM has given opportunity to relate the research to a given theoretical framework. Other presentations include talks at the DMM project and internally at CTI's seminar.

Appendix B - Web-use

Conditions

This is a description of the Danish textile and clothing industry's use of web-based technologies in 2000. The performed analysis considers the application of e-mail and homepages but do not include information on EDI-usage, video-conferencing and Internet-based CAD/CAM.

The analysis below is based on online investigation of the members of the Federation of Danish Textile and Clothing, available at textile.dk. Additional data on their financial situation, number of employees etc. has been derived from other online services notably borsen.dk, and greens.dk. Accessible membership base contained 263 businesses.

Membership of the federation has been the essential criteria for selecting the sample. Membership is though important as this indicates an industrial affiliation irrespective of product and business codes. However, membership as criterion makes the sample somewhat biased as the members tend to be more established than the average industrial firms, larger than average.

The federation members represent all steps of the industrial value chain from initial yarn processing over manufacturing to agencies and retail. The members belong to the federation, even though some of them – strictly speaking – do not belong to the industry at large: That is, some of the firms are registered as providing other products or services which are not included in the business codes for textile and clothing industries e.g. cleaners and industrial designers.

Overview

Textile and clothing businesses are describable according to a range of variables such as their web-usage, location, age, size and degrees of specialisation. A schematic presentation is offered below:

	Firms	Web-value	Year	Ave. Employees	Ave. Branded firms	Ave. Brands
In district	149	3,5	1966	43	0,5	1,6
Outside district	114	2,9	1964	40	0,6	1,5
Total	263	3,2	1965	42	0,6	1,6

Firms from the district are better presented in the Federation than those outside. Otherwise the firms seem quite similar regarding average age, and number of employees. Slightly fewer businesses within the district are branded, but the average number of brands is slightly higher. A noticeable difference is however appearing when it comes to web-values, where the district-based firms seem to provide larger degrees of Internet-based communication-tools.

	Clothing		**Textile**		**Services**	
	Firms	Ave. Functions	Firms	Ave. Functions	Firms	Ave. Functions
In district	108	1,6	36	1	34	1,1
Outside district	77	2,2	33	1	19	1,1
Total	185	1,8	69	1	53	1,1

Note: a) functions accounts for the registered number of value adding steps or categories of final product, divided by the number of specialised firms in the area.

Whereas there are hardly any differences between the degrees of specialisation of textile and service-providing firms inside and outside the district, it is evidently different for clothing manufacturers. Indeed, clothing businesses inside the district are much more specialised as they only perform 1,6 value-adding functions in average. Those outside perform 40 percent more functions in average.

Variables

Analysis on applied web-technologies includes e-mail and homepages, where each firm is given a point for having an e-mail account, for having had a hp, and for having a hp. Additional points are given for the hp that presents the firm, the products, both firm and products, and also for online sales. The range of scores is thus as follows:

Scores for applying web-based technologies i.e. web-value

Feature	Total score
E-mail	1
Homepage under construction	2
Homepage with firm profile	3
Homepage with product info.	4
Homepage with firm and product info.	5
Online sales	6

Points on web-use spans from 0 to 6 where the more demanding the technology, the higher is the score. Assuming that there are some common features amongst firms with the same web-score, the 263 businesses have been grouped into 7 categories representing the values 0-6. Of the 263 it has only been possible to get economic information about 222 firms. The analysis has then established a range of possible explanatory factors:

Branch value (1-5): denoting the industrial branch and position in the value chain based on 7-digit branch codes. Values are 1: preparations, 2: textile production, 3: textile clothing, 4: clothing, and 5: wholesale.
County (0-1): denoting location inside Ringkøbing County based on postal codes (6900-7830).
District (0-1): denoting location inside Herning-Ikast industrial district in the eastern part of Ringkøbing County: based on postal codes (7330-7451).
Employees: number of employees.
Year: the year of establishment.
Brands: number of brands registered at the Federation.
Functions (1-3): indexed value for areas of commercial activities i.e. textile, clothing, and services.
Net. Profits: Profits from core activities after taxes 1999-2000, in mio. DKr. (N = 222).

Result 1 (N=222)

Results from the statistical analysis are presented below.

Web-value	N	Av. branch value	Av. function	Av. County	Av. district	Av. employ.	Av. brands	Av. Profits
0	41	3,7	1,3	0,6	0,5	18	0,7	7,3
1	39	3,6	1,3	0,7	0,6	29	1,1	12,4
2	22	3,5	1,4	0,6	0,5	36	1,3	15,1
3	10	3,3	1,4	0,7	0,4	68	1	15,9
4	24	3,8	1,1	0,6	0,4	24	0,8	10,8
5	80	3,4	1,1	0,5	0,4	69	2,9	29,4
6	6	4	1	0	0	91	2,8	26,3
Total/ average	**222**	**3,6**	**1,3**	**0,6**	**0,4**	**42**	**1,6**	**18,2**

Just over 20 percent do not have e-mails nor homepages i.e. web-value equal to 0, and just under 20 percent only had e-mail account but no homepages, which leaves 60 percent with both. Of all the firms

over 30 percent provided information on business as well as products, but only very few provided direct sales opportunities or information.

Regression 1

Regression analysis is based on the following general equation:

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + ... + \beta_n x_n + \varepsilon$$

Where Y is the explained variable α is a constant, x_1 to x_n are n variables with the coefficients β_1 to β_n. ε is a minor residual, where the sum of all the ε's equals zero. This equation is phrased slightly different in this particular context:

$$\text{Web-value} = \text{Constant} + \beta_1 \text{ Function} + \beta_2 \text{ District} + \beta_3 \text{ Employees} + \ldots + \varepsilon$$

Variables	Coefficient	Confidence
Constant	14,4	98 %
Function	- 12,0	99 %
Brands	- 4,9	97 %
Net. Profits	0,6	98 %

The regression analysis based on this data has shown to explain 97 percent of the variation in web-values, and all the above variables have good explanatory powers as they fall within the confidence interval of 95 percent.

Analysis

Regression analyses indicate that the differences in web-use can be ascribed to combinations of "function" (i.e. number of value adding activities), number of "brands", and "net. profit". The size of the firm measured as the number of "employees" has no individual contribution, which may be due to correlation with profit-rates. The fewer value-adding functions a business perform i.e. the more specialised, the more probably it is that they score high on web-value. Similar conditions appear for the number of brands, where the fewer bands, and more specialisation, the more likely they are to score high on web-value. Last significant term is the net profits, which reflect that the higher the

profits the higher the web-value. Unfortunately it is not possible to indicate weather higher profits leads to more web-use or if high web-values lead to higher profits.

No matter how interesting these results are, they are quite interesting on the factors that have to be omitted: “branch value” has no individual contribution to the regression i.e. it doesn’t matter if the manufactured products and services are targeted early or late stages in the value chain. And geographical location either in district or county has no explanatory powers.

Result 2 (N = 263)

Results from the statistical analysis are presented below.

Web-value	**N**	**Av. branch value**	**Av. function**	**Av. County**	**Av. district**	**Av. employees**	**Av. brands**	**Av. year**
0	58	3,7	1,4	0,6	0,4	15	0,6	1969
1	49	3,6	1,3	0,7	0,6	27	1,0	1971
2	31	3,5	1,3	0,5	0,4	28	1,1	1964
3	10	2,9	1,4	0,7	0,4	81	1,0	1954
4	26	3,8	1,1	0,6	0,4	26	0,9	1977
5	84	3,4	1,2	0,5	0,4	71	2,9	1959
6	5	3,8	1,0	0,0	0,0	109	2,8	1948
Total/ average	**263**	**3,6**	**1,3**	**0,6**	**0,4**	**42**	**1,6**	**1965**

Regression 2

Variables	Coefficient	Confidence
Constant	- 532,8	97 %
Branch value	- 6,3	98 %
District	- 16,6	98 %
Brands	2,0	97 %
Year of establishment	0,3	97 %

The regression analysis based on this data has shown to explain 99 percent of the variation in web-values, and all the above variables have good explanatory powers as they fall within the confidence interval of 95 percent. This second regression has a marginally higher explanatory value and may thus be preferred to the first regression, however this second regression is based on more businesses with the omission of data on net profits. As net profits were one of the significant factors of regression 1, it must be questioned to which extent this second regression is preferable.

Analysis

Regression analyses indicate that the differences in web-value can be ascribed to combinations of "branch value" (i.e. position in value chain), "district" location, number of "brands", and "year of establishment". Surprisingly the size of the firm measured as the number of "employees" has no individual contribution, nor has the variable "function", which is an indicator for degrees of specialisation.

The significant factors are "brands", which indicate that the more brands the more likely the firm is to score high on web-value. This runs counter to the previous analysis and must hence be questioned. The age of the company is also significant as the younger the firm is the more likely it is to apply the investigated web-technologies. Geographical location of the firm is also important in this regression: firms outside the district have higher web-values than those inside, which is a result of the low number of high-scoring firms within the district. And finally "branch value" also contributes to the explanation as the higher the value i.e. the closer to final sales the less likely it is that the firm apply e-mail and advanced homepages, which is surprising. It would have been more obvious that firms closer to the final consumption also provide the most information through their web-pages, but this seems to be irrelevant. Instead the surprising negative coefficient can be explained by the purpose of web-pages as virtual business-presentations towards other businesses, and hence will businesses positioned early in the value chains need to display more information and score higher.

Data-profile for web-value = 3 is somewhat deviating, also expressed in abnormal residuals. This data set is only composed of 10 observations, well below the average of the others, have more than average employees and less than average branch value. Detailed investigation has indicated that this data set is composed of textile producing companies, which are larger than industrial average and apparently have problems with displaying their products. However, alternative regression models, where homepages with presentation of either firm or product information is given same web-value, do not give any clear analysis.